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NEW SPECIES OF *CEROTAINIOPS* CURRAN (Diptera: Asilidae)

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Professor of Entomology, Oregon State College

Cerotainiops Curran

1930. *Cerotainiops* Curran, Amer. Mus. Novit. No. 415:11. Type species: *Cerotainiops rufiventris* Curran.
1934. *Cerotainiops* Curran, The families and genera of North American Diptera. The Ballou Press, New York, p. 179.
1942. *Cerotainiops*, Pritchard, Jour. Kansas Ent. Soc. 15:19-24.

In 1942 Pritchard revised the genus *Cerotainiops* Curran, considering *rufiventris* Curran, *atripes* (McAtee), and *similis* (Brown) as synonyms of *Cerotainiops abdominalis* (Brown); also he described *oma* and *wilcoxi* as new species. In addition to these three species, the present author is adding three more undescribed species to the genus.

The presence of short, upturned marginal hairs on the scutellum was used by Curran (1934) as one character in his key for separating *Cerotainiops* from *Panamasilus* Curran. Actually, as *Cerotainiops* is known at the present, only the type species has scutellar marginal hairs while the other five species have long scutellar bristles. The short pyriform antennae of *Cerotainiops* readily separate it from *Panamasilus*, with its elongate third antennal segment. All six species possess the strongly flattened second palpal segment that is characteristic of *Cerotainiops*.

Pritchard in his revision describes *Cerotainiops* as a genus of fast fliers. The writer's collecting experience has been that they are more or less easily captured but difficult to find even though resting on bare soil. However, *mcclayi*, new species, rests on sedges, so that it is easily seen and captured. As Pritchard indicates, specimens of *Cerotainiops* are in general rare. This is illustrated in the present paper by the fact that many distribution records represent only one or two specimens.

The writer wishes to express his thanks to the following for loan of material: Mr. A. T. McClay, University of California (Davis); Dr. P. D. Hurd, Jr., University of California (Berkeley); Dr. W. W. Wirth, U.S. National Museum. The late Dr. R. H. Beamer had submitted material for identification from the Snow Entomological Museum, University of Kansas.

Key to *Cerotainiops*

1. Scutellum with a fringe of short, upturned, marginal hairs (Kansas, Oklahoma, Texas, New Mexico, Arizona, California) ..... *abdominalis* (Brown)
Scutellum with long, marginal bristles 2

[1] Grant-in-aid funds from Oregon State College contributed to the financing of these studies.

2. Thoracic pleura largely bare of pollen, shining; posterior femora blackish (Arizona, California) ..... *oma* Pritchard
   Thoracic pleura completely pollinose 3
3. Abdominal segments thinly white pollinose; female with narrow subshining bands posteriorly; male abdominal segments 2 to 4 with a median, short, narrow, subshining band connecting two larger subshining areas posteriorly, small subshining areas at the bases of the lateral bristles (Texas) ..... *lucyi*, new species
   Abdomen either bare or with pollen confined to the lateral margin 4
4. Abdomen orange, bare, subshining (Arizona, California, Chihuahua) ..... *wilcoxi* Pritchard
   Abdomen laterally whitish pollinose 5
5. Thorax grayish white pollinose, with inconspicuous short hair California) ..... *kernae*, new species
   Thorax yellowish brown pollinose, with numerous scattered, short bristles and medially three longitudinal rows of short, more or less reclinate bristles (California) ..... *mcclayi*, new species

Cerotainiops lucyi, new species

This species is easily separated from the others by the uniformly yellowish red ground color of the whole body, and by the similar color of most of the bristles.

Male: Length 8 mm. Face and vertex white pollinose, occiput grayish white pollinose; mystax mostly of white hair, with a few yellow hairs below and laterally, a few black hairs medially; bristles on first antennal segment, vertex and occiput reddish; second antennal segment with a black bristle below; antennae reddish, length of the two proximal segments about equal to the third, the latter more globular than the third segment of *abdominalis*, with basal pedicel; proboscis black below, yellowish red above.

Thorax with ground color red, white pollinose, with geminate olive brown median stripe extending to pronotum and posteriorly falling short of scutellum; two broad olive brown lateral stripes divided at transverse suture by a narrow, white pollinose line; pleura white pollinose; scutellum white to tan pollinose including the posterior margin, sparsely setose; margin with 5 long reddish bristles.

Abdomen white pollinose, except first abdominal segment olive brown anteriorly; abdominal segments 1 and 5 with a narrow subshining band on posterior margin, segments 2 to 4 with a narrow, median, subshining band connecting two broader subshining areas; subshining spots around bases of bristles on the lateral margins of abdomen; abdomen clothed with recumbent white and orange setae.

Legs subshining, reddish, darker dorsally, with reddish bristles and white recumbent setae; hind tibiae arcuate.

Wings hyaline.

Female: Similar to male. Scutellum with 8 marginal bristles; abdominal segments 2 to 5 with narrow subshining stripes posteriorly, expanding laterad only slightly, except segment 5; no subshining areas at bases of the lateral bristles.

Types: Holotype, male, Westbrook, Texas, April 7, 1954 (Lucy D.

Beamer). One antenna is missing, the remaining one has been repaired by the writer. Allotype, female, same locality and date as holotype (R. H. Beamer). Paratypes, four females, same data as holotype and allotype. Holotype, allotype, and one paratype deposited in the Snow Entomological Museum at the University of Kansas. The other paratypes are in the collection of the author.

Remarks: This species is dedicated to Mrs. Lucy D. Beamer who has collected many fine species of the Asilidae.

Cerotainiops mcclayi, new species

This species and *Cerotainiops kernae*, new species, are easily separated from the other five in this genus by the pollinose lateral margins of the abdomen. *Cerotainiops mcclayi* has on the thorax three medial longitudinal rows of short, more or less reclinate bristles that *kernae* lacks.

Male: Length 10 mm. Head ground color yellowish red; face, vertex, and occiput above yellowish white pollinose, occiput below grayish white; hair in mystax, on lower occiput and palpi white; bristles on antennae, ocellar tubercle and occiput yellowish white. Proboscis black; antennal segment 1 yellowish red, segments 2 and 3 ground color liver brown, with grayish to yellowish white coarse pollinosity that obscures the ground color in some lights.

Thorax ground color dark reddish brown, dorsum light brownish yellow pollinose; median geminate stripe brown and divided by a yellowish brown stripe wider anteriorly than posteriorly; two large lateral brown stripes divided by a brownish yellow line along the transverse suture; three strong, straw-colored supraalar bristles, two postalars similar; scutellum light brownish yellow pollinose, sparsely white setose, with four pale marginal bristles; pleura brownish yellow pollinose.

Abdomen with ground color yellowish red, yellow setose, subshining dorsally, lateral margins broadly yellowish white pollinose, segment 1 with some pollen along anterior and posterior margins; segments 2 to 6 with single, lateral, pale bristles.

Legs with femora dark reddish, tibiae lighter, bristles and hairs pale.

Wings hyaline, posterior margin and tip faintly darkened.

Female: Similar to male; antennal segments 2 and 3 black, segment 2 reddish basally, pollinosity mixed gray and light yellowish brown; abdomen laterally with a broader pollinose stripe than on male, the pollinosity extending along the anterior margin of each segment almost to the middle, segment 1 pollinose except medially; wings more distinctly and uniformly darkened than on male.

Types: Holotype, male, 5 miles north of Warner Springs, San Diego County, California, June 27, 1958 (Dorothy W. Martin). Allotype, female, same data as for holotype. Paratypes, twenty-four specimens and one mating pair, same data as for holotype and allotype; twenty-four specimens and one mating pair, same locality, July 8, 1958; one male, 2 miles north of Warner Springs, San Diego County, California, July 4, 1956 (H. R. Moffitt), one female, same data (R. W. Bushing). The holotype, allotype, and a series of paratypes are deposited in the collection of the University of California (Davis). Other paratypes are in the collection of the writer.

Remarks: This species is dedicated to Mr. A. T. McClay, Senior Museum Entomologist, University of California (Davis), who has sent many rare and many undescribed species of Asilidae to the writer for identification.

Cerotainiops mcclayi was collected along the sandy shore of a dry stream bed. The flies were resting on a sedge that was showing signs of drying. Collecting up and down this wash indicated that the distribution of the flies was limited to near Warner Springs. Apparently there was a correlation with the distribution of the sedge. In the past, Mr. Joe Wilcox, an avid and veteran collector of Asilidae, has collected in this particular area but never found this species. The number of specimens taken is very unusual for this genus. The first collectors of the species apparently were able to find only one each.

Cerotainiops kernae, new species

Cerotainiops kernae is similar to *mcclayi* in having the lateral margins of the abdominal segments pollinose but differs in being without the longitudinal rows of short bristles on the thorax.

Female: Length 9 mm. Head black, vestiture white except the black bristle on antennal segment 2; antennal segment 1 yellowish red, segments 2 and 3 dark reddish brown, segment 2 white pollinose, segment 3 brownish white pollinose.

Thorax black, grayish white pollinose, with two widely separated, medial, polished, short, longitudinal stripes anteriorly; dorsum abraded posteriorly obscuring any pattern that might have been present; one supraalar bristle, one postalar; dorsum white setose; scutellum white pollinose, disc seemingly partially abraded on type specimen; two marginal bristles; pleura white pollinose.

Abdomen orange red; white setose, white pollinose laterally; segment 1 narrowly pollinose along anterior margin.

Legs with femora bluish black, tibiae lighter, reddish basally.

Wings hyaline, slightly darkened at tip.

Type: Holotype, female, Kernville, California, July 24, 1940 (D. E. Hardy). Deposited in the Snow Entomological Museum, University of Kansas.

Remarks: This specimen was collected near the original site of Kernville that is now inundated by the waters of Isabella Lake. Since the collection of this specimen the city of Kernville has been moved northward 10 or 12 miles to a higher elevation but as formerly is still on the banks of the Kern River. In 1958 the writer made two trips to the general area of both the old and the new sites but was unable to find this species.

Cerotainiops abdominalis (Brown)

The range of this species is from Kansas southward into Texas and westward into southern California.

Cerotainiops oma Pritchard

At the time this species was described, Pritchard had specimens from Los Angeles County, California. The following records greatly extend the range of this very distinct species and also suggest that the species is most

likely to be collected during the spring of the year. Each record is represented by only a single specimen, with one exception:

Arizona. Santa Rita Mountains, April 29, 1953 (R. M. Bohart).

California. San Diego County, Borrego, April 26, 1954 (P. D. Hurd); April 24, 1955 (E. I. Schlinger); two specimens, Borrego Valley, dunes, April 18, 1957 (H. R. Moffitt), (E. I. Schlinger); Monterey County, Arroyo Camp, June 6, 1956 (R. C. Bechtel).

Cerotainiops wilcoxi Pritchard

Most of Pritchard's records for this species are for Arizona. His only California record is for Blythe, which is on the Arizona border. In spite of the long period that this species is on the wing, May to August, these additional records are each represented by single specimens, with one exception:

Arizona. Two specimens, Beaver Dam Wash, June 30, 1949 (Chas. H. Martin); Quitobaquito, Organ Pipe Cactus National Monument, May 1, 1953 (A. & H. Dietrich).

California. San Diego County, 10 miles south of Coachella, May 10, 1956 (T. R. Haig). Riverside County, Palm Springs, August 24, 1948 (Chas. H. Martin); Cathedral City, July 13, 1951. San Bernardino County, 13 miles west of Ilyomar Junction, August 20, 1950 (R. S. Schuster).

Mexico. Chihuahua, Juarez, 13 miles south, August 18, 1952 (E. E. Gilbert & C. D. MacNeil).

BEEFLY PARASITISM OF THE AMERICAN CARPENTER BEES BELONGING TO THE GENUS *XYLOCOPA* LATREILLE (Diptera; Hymenoptera)

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University of California, Berkeley

During the early autumn of last year, while I was headquartered at the Southwestern Research Station* of the American Museum of Natural History near Portal, Arizona, a number of nests of *Xylocopa californica arizonensis* Cresson were discovered in the environs of nearby Rodeo, New Mexico, which contained active pupae of a large bombyliid. These nests were collected and returned to the laboratory for observation.

The results of these studies together with a review of the several accounts reporting parasitism of the American *Xylocopa* are discussed under the various carpenter bee species known to serve as hosts for this family of flies.

* I very gratefully acknowledge my indebtedness to Dr. Mont A. Cazier, Director of the Southwestern Research Station, who contributed importantly to the success of my investigations undertaken there during August and early Sepember of 1958. Dr. E. G. Linsley assisted in the collection of the carpenter bee nests.

Although the beefly identifications recorded in the literature pertaining to the bombyliid-*Xylocopa* relationship reflect to a large degree the systematics of the era, Dr. Frank R. Cole informs me that all of these identifications, except possibly that of *Anthrax sinuosa* Wiedemann which may be a misidentification, are probably referable to *Anthrax simson* Fabricius, a species which ranges from Argentina into the United States.

Four American species of *Xylocopa* are now known to be parasitized by Bombyliidae. Two of these carpenter bees, *Xylocopa californica arizonensis* Cresson and *X. virginica virginica* (Linnaeus), belong to the Nearctic subgenus *Xylocopoides* Michener. *Xylocopa augusti* Lepeletier, which is a member of the very large Neotropical subgenus *Neoxylocopa* Michener, is the only species thus far recorded from South America to harbor these flies. The western North American *Xylocopa tabaniformis orpifex* Smith of the subgenus *Notoxylocopa* Hurd completes the list of the recorded carpenter bee hosts. It is anticipated that a great many of the remaining 150 carpenter bee species of the Americas ultimately will be established as hosts of these flies.

While the life cycle of the beefly parasite in relation to its carpenter bee host is still imperfectly known, some idea of it is already evident in the following accounts of our knowledge concerning this relationship.

Xylocopa tabaniformis orpifex Smith

On two occasions nests of this carpenter bee have been found to be parasitized by *Anthrax simson* Fabricius. Davidson (1893) in his study of the bee, which he observed nesting during June and August 1892 on Mt. Wilson, Los Angeles County, California, comments that he and D. W. Coquillett found numerous pupae (successfully reared to adults) of the beefly in the nest cells and regarded it as "chief among the enemies" of the bee. He notes that the very active pupa, aided by its rings of hooked hairs, gradually wriggled itself through the nest partitions to the burrow entrance, where it transformed, leaving its pupal case hanging at the edge of the nest opening.

Nininger (1916:162-163) has provided the most complete and informative study thus far made on the parasitism of the beefly *Anthrax simson* Fabricius (as *Spongostylum delila* Loew) in the nests of *Xylocopa*. His studies, which extended over a period of more than one year, commenced on September 29, 1915, and were conducted on a small mountain of approximately 3,500 feet elevation in San Dimas Canyon, San Gabriel Mountains, Los Angeles County, California. He found that the beefly first appears upon the pollen provisions within the cell as a very minute but exceedingly active larva. After three or four weeks of endlessly creeping about the nest cell and feeding on the pollen stores, during which time the host egg has hatched and the bee larva has commenced to grow, the beefly larva attaches itself by means of its hooked proboscis to the sixth or seventh segment of the developing *Xylocopa* larva and commences to feed. On occasion the writhing movements of the bee larva may dislodge the parasite, but it soon reattaches itself and resumes its feeding. At the time the small (3-5 mm.) beefly larva begins to feed it is four or more weeks of age. During the first two weeks of host feeding its growth is scarcely perceptible, so that at the age of five

or six weeks its length does not exceed four or five millimeters. From this point on, however, it commences to grow at a rate which results in almost doubling of its size within twenty-four hours. The host larva which previously appeared unaltered now rapidly begins to shrivel. After five days

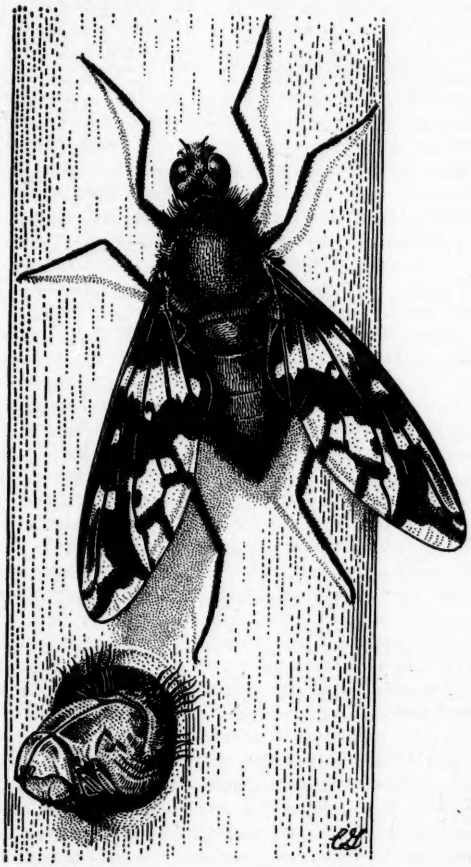

Fig. 1. *Anthrax simson* Fabricius shown shortly after its emergence from the pupa protruding at the nest entrance of *Xylocopa californica arizonensis* Cresson. Drawing prepared by Celeste Green, Scientific Illustrator, University of California, Berkeley.

of this accelerated feeding the bee larva is reduced to an empty skin. Nininger found that the fully grown beefly larva remains almost motionless for some ten or twelve days, after which it becomes a little more active, then

moults about two days later and becomes a pupa. Some fifteen to twenty days are spent in this stage, after which the adult beefly emerges.

These investigations revealed that approximately 10 per cent of bee cells examined during this particular season were affected by the parasite. About one half of the carpenter bee nests studied contained only one parasitized larva and in only one instance did Nininger find more than one parasitized bee larva in the same nest.

Xylocopa virginica virginica (Linnaeus)

Several instances of parasitism by flies of the genus *Anthrax* have been recorded for this common carpenter bee of the eastern United States. The first of these was presented by Angus (1868:157), who forwarded to Dr. A. S. Packard the pupae of this bee together with a pupa of a beefly identified as *Anthrax sinuosa* Wiedemann. These were obtained from adjacent cells in a nest collected at West Farms, New York. Subsequently, Packard (1868:369-371), utilizing another nest and additional observations supplied by Angus, presented an account of the nesting habits of this carpenter bee. In that report Packard comments that in a nest sent by Angus were to be found ". . . cells and young in various stages of growth, together with the larvae and chrysalids of *Anthrax sinuosa,* a species of fly parasitic on the larva which buries it head in its soft body, and feeds on its juices."

In the following year, Angus (1869:48-49) sent to the editors of the American Naturalist a statement accompanied by wood shavings to which were adhered eggs believed to be those of *Anthrax sinuosa.* The editors were unable to confirm the identification since the eggs had dried up so that they were unrecognizable. Angus (*ibid.*) noted, however, that he had been able, by exerting pressure with a pin on the eggs, to obtain small larvae which compared favorably with the earliest *Anthrax* larvae associated with the *Xylocopa* he had under surveillance. Angus had secured the eggs ". . . about the openings of a *Xylocopa* cell . . ." [? nest entrance] where some time earlier he had seen an adult *Anthrax* hovering in flight. Unfortunately, the date of these observations was not given.

As near as I can ascertain, the foregoing information prompted Osten Sacken (1886:100) to remark that *"A. simson* is in the U.S. said to be a parasite of *Xylocopa virginica."* Almost certainly Riley (in Howard, 1893: 332) similarly founded his observation: "it would be interesting to record the fact that this genus [*Xylocopa*] is parasitized by *Anthrax,* which is also parasitic on so many other boring bees, and insects of like habits."

Rau (1926:164-165) in attempting to account for the marked reduction in the population of *Xylocopa virginica* (Linnaeus) inhabiting porch timbers at Wickes, 20 miles south of St. Louis, Missouri, came to the conclusion that it was related to the "abundance of shedding-skins of the silver-winged parasite, *Argyramoeba tigrina* (currently *Anthrax simson* Fabricius), adhered to the wooden rafters about the bees' tunnels; hence it is probable that this parasite was largely responsible for the small number of bees, as well as of the mud wasps, *Monobia quadridens,* and the grasscarrier wasps, *Chlorion* (*Isodontia*) *auripes,* which occupied the old tunnels of the carpenter-bees." Rau, however, was unable to demonstrate conclusively that this beefly was parasitic in the carpenter bee nests even though he observed

that there was "an enormous increase at that time in the number of adults of the *A. tigrina* parasite." In a later paper Rau (1933:262) altered these conclusions and stated that the observed reduction in the population of carpenter bees was not to be attributed to the beefly, which he concluded affected only the appropriators of the carpenter bee burrows and not the *Xylocopa,* but rather to the rigors of the preceding winter.

I am inclined to believe that Rau was partly misled in this interpretation by his observation that the adults of the parasite "appeared at a time when *Xylocopa* were in the adult stage and no young were then on hand to be infested." This appearance of the beefly adults at a time when the carpenter bee nesting site contains only pupae or adult bees is precisely the situation that I observed in the early autumn (September) in the case of *Xylocopa californica arizonensis* Cresson and its parasite *Anthrax simson* Fabricius, near Rodeo, New Mexico. Since the carpenter bees in the Rodeo nesting site were either in the pupal state or were already emerged and congregating in the used nesting tunnels (onset of hibernation), there did not exist suitable conditions for the development of a subsequent generation of the beefly, which requires newly provisioned cells. This state of affairs suggests that the apparent lack of cyclical synchrony between the bee and its parasite must be compensated in some manner so that the beefly will be able to parasitize the newly provisioned carpenter bee nest cells of the following year. One possibility is that the beefly could, like its host, overwinter as an adult in the abandoned nesting tunnels. This seems unlikely in view of the type of organism involved. It is also possible that a female beefly might emerge from these late summer and early fall carpenter bee nests, mate, and then seek out an alternate host and parasitize it, with her progeny spending the winter undergoing metamorphosis and emerging in the succeeding year in time to parasitize the newly constructed carpenter bee nests. However, it is more likely that under these late seasonal conditions, the emerging beefly mates and then deposits its eggs in or near the abandoned or occupied (pupae or adult bees only) carpenter bee nests. These eggs hatch, and since there are no bee cells suitable for parasitization they overwinter as first instar larvae which, in the following year, infest the newly built carpenter bee nests. Since it has been established that at least certain Bombyliidae overwinter in this very manner, it is anticipated that these will also be found to do so.

Xylocopa californica arizonensis Cresson

Even though this carpenter bee was found nesting quite commonly in the dead flower stalks of *Yucca* and Yucca-like plants (*Agave, Dasylirion,* and *Nolina*) in the vicinity of the Southwestern Research Station near Portal, Arizona, this past summer, only one nesting locality was found to be parasitized by the bombyliid fly, *Anthrax simson* Fabricius (det. F. R. Cole). At this locality, which is situated approximately one and one-half miles south of Rodeo, Hidalgo County, New Mexico, a number of carpenter bee nests, which had been constructed in the dead flower stalks of an extensive grove of *Yucca elata* Engelm., were collected on September 10, 1958, by sawing the stalks at a short distance above their junction with the main plant. During these operations a very large and newly voided bom-

byliid pupal case was observed protruding from a nest entrance (as in fig. 1). Upon return to the laboratory the stalks containing the various nests were split open longitudinally. Three of the ten nests examined contained pupae of the beefly. One of the nests had two fly pupae together in the two uppermost cells, the six cells towards the entrance each being occupied by a carpenter bee pupa. The other parasitized nests consisting of six cells (five with carpenter bee pupae) each had a single beefly pupa in the second cell from the nest entrance.

The bombyliid pupae were removed from their associated carpenter bee pupae and placed individually in earlier collected single celled carpenter bee nests within sealed pint jars. Within less than three weeks perfect adult beeflies were obtained. The collection of the California Insect Survey contains a pupa of *Anthrax simson* Fabricius taken on August 14, 1952, by Mr. John D. Lattin, from a nest of *Xylocopa californica arizonensis* Cresson, constructed in the dead flower stalk of a *Yucca,* 40 miles southeast of Nuevas Casas Grandes, Chihuahua, Mexico.

Xylocopa augusti Lepeletier

Many of the cells in a nest of this species located on January 13, 1956, in a hardwood fence post at Araucaria, Paraná, Brazil, were found by Dr. C. D. Michener and Padre J. S. Moure to contain larvae and pupae of an undetermined bombyliid (Hurd, 1958). This is the first record of beefly parasitism of a South American *Xylocopa*. Since *Anthrax simson* Fabricius is known to occur in the vicinity where the nest was located, it quite possibly may have been the species involved.

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A NEW SPECIES OF *EPHEMERELLA* FROM OREGON (Ephemeroptera: Ephemerellidae)

RICHARD K. ALLEN[1]

Through the kindness of Drs. P. O. Ritcher and F. F. Hasbrouck, the entire Oregon State College collection of Ephemeroptera was made available to the author for determination and study. Included in this material were some undescribed nymphs of the *heterocaudata* group which were tentatively placed as *Ephemerella jacobi* McDunnough (Allen and Edmunds, 1956). Additional study has shown these nymphs to be an undescribed species which I take great pleasure in naming in honor of Dr. G. F. Edmunds, Jr. in recognition of his contribution to our knowledge of the mayflies of western North America. I would like to thank Mr. David I. Rasmussen for preparing the figures.

Ephemerella edmundsi n. sp.

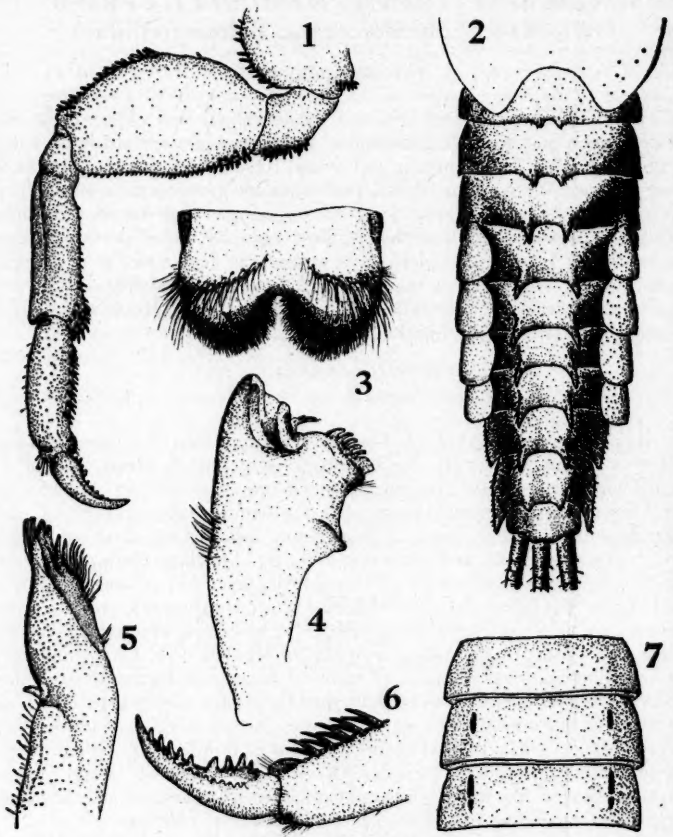
1956. Allen and Edmunds. Proc. Utah Acad. Sci., Arts and Letters, 33:87 (*E. jacobi?*, in part).

Mature nymph (in alcohol). Length: 7-7.5 mm.; cerci 5-6 mm.; terminal filament 8-9 mm. General color uniformly light brown. Head without occipital tubercles; antennae brown; canines blunt, rounded (fig. 4); maxillae with minute, one-segmented palpi (fig. 5). Thorax without tubercles, each sternite with a median patch of short heavy spines. Legs short and thick, with numerous dorsal and ventral spines (fig. 1); claws with double row of denticles, anterior row with 10-14 small denticles and posterior row with 9-12 larger denticles (fig. 6). Abdomen with conspicuous, paired, dorsal submedian spines on segments 1-9 (fig. 2); base of spines narrow on segment one, gradually increasing in width to segment five, narrowing again on segments six to nine; apices of spines divergent on segments 4-8; spines short on segment one, gradually increasing in size to segment seven, decreasing in size on segments eight and nine; lateral margins of tergite eight produced into weak postero-lateral projections, tergite nine with moderate postero-lateral projections; sternites 4-8 with dark dashes on lateral margins (fig. 7). Caudal filaments light brown with whorls of spines at junctions of segments; cerci about two thirds as long as terminal filament.

Holotype: Mature male nymph, Woods Creek, Benton Co., Oregon, 13 May 1937, collected by "Niot," in collection of California Academy of Sciences. Paratypes: 3 female nymphs, McKenzie River, Oregon, 9 March 1939, collected by "J.E.D.," two in collection of University of Utah, one in collection of Oregon State College; 1 female nymph, Fall Creek, Oregon, 3 May 1940, collected by N. L. Sieg, in collection of Oregon State College.

Remarks: *Ephemerella edmundsi* is the fifth species named in the *heterocaudata* group and may be distinguished from the nymphs of the other species by the distinctive dorsal abdominal tubercles, the unique color pattern of the abdominal sternites, the dentition of the claws and by the extreme reduction of the maxillary palpi. Allen and Edmunds (1956) re-

[1] Research Fellow, University of Utah. The research on which this report is based was supported by grants from the University of Utah Research Fund.



EXPLANATION OF FIGURES

Figs. 1-7. *Ephemerella edmundsi* n. sp., mature female nymph, paratype. Fig. 1. foreleg. Fig. 2. dorsal view of abdomen. Fig. 3. labrum. Fig. 4. left mandible. Fig. 5. maxilla. Fig. 6. claw of right foreleg. Fig. 7. 3rd, 4th and 5th sternites.

ported *E. edmundsi* as probably the nymph of *E. jacobi* McDunnough, but examination of a paratype adult female of the latter species has made this association seem unlikely.

LITERATURE CITED

Allen, R. K. and G. F. Edmunds, Jr. 1956. A list of the mayflies of Oregon. Proc. Utah Acad. Sci., Arts and Letters, 33:85-87.

BIOLOGY OF THE BLACK-LEGGED TICK[1]

Robert L. Harris[2]

Introduction

The black-legged tick, *Ixodes scapularis* Say, is the second or third most common tick attacking livestock in Arkansas. There is no estimate of losses caused by this tick. The adult is a common pest of hunting dogs and causes some loss to cattle during the winter months. Immature stages rarely attack domestic animals. Losses caused by the black-legged tick are a result of bloodsucking and irritation. It is a possible disease vector, but there is very little experimental evidence to demonstrate this.

This paper reports the results of studies on the biology and seasonal occurrence of the black-legged tick, with particular attention to the effects of temperature and relative humidity. The work was conducted at Fayetteville, Arkansas, from November, 1956, to November, 1957.

Review of Literature

Very little work has been done on the biology of the black-legged tick. Hooker et al. (1912) in their monograph reported work on the life cycle under insectary conditions. A summary of their report is as follows: Engorged females began ovipositing in 15 to 17 days after falling from the host, and eggs began to hatch in 72 days at a mean temperature of 61° F. The larval feeding period averaged 3.7 days when larvae were fed on a bovine host, and engorged larvae transformed to nymphs in an average of 26 days at a mean temperature of 77° F. The nymphal feeding period on a bovine host averaged 5.9 days, and engorged nymphs required an average of 40 days to transform to adults at a mean temperature of 82° F.

Rees (1934) conducted experiments in which three females engorged on a bovine host. The time required for engorging was from 14 to 16 days, while one female engorged on a dog in seven days. These four females failed to oviposit.

The immature stages of the black-legged tick have a rather wide host range. Bequaert (1945) states that their normal hosts are small mammals, particularly the white-footed mouse. While the adults attack a variety of large and medium-sized mammals, Hooker et al. (1912) state that immature stages will also attack lizards and certain birds.

Methods and Materials

Engorged female ticks were collected from dogs in Madison County, Arkansas, from November, 1956, to April, 1957. Each was placed in a glass tube about one inch in diameter and 3 inches in length. The tubes were sealed at both ends with one-hole stoppers, and the holes were covered with 90-mesh Saran cloth cemented on with Duco cement. The tubes were then placed in relative humidity chambers and controlled temperature cabinets at

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the different relative humidity and temperature combinations desired. The combinations used were 80% R.H. and 80° F., 90% R.H. and 70° F., 80% R.H. and 70° F., 60% R.H. and 70° F., 90% R.H. and 60° F., 80% R.H. and 60° F., and 60% R.H. and 60° F. A total of 86 ticks were used in these tests. The number of ticks subjected to each combination varied. Desiccator jars were used as relative humidity chambers. The relative humidity was controlled by the use of potassium hydroxide (Peterson, 1953). The 100% relative humidity was obtained by use of 100 ml. of water and no potassium hydroxide.

The ticks oviposited and the eggs hatched in the glass tubes without being disturbed, except for occasional changing of moldy stoppers. The ticks were observed daily and date of oviposition and hatching recorded.

Larvae were brushed on the ears of the rabbits, where they attached and engorged. The ears were covered by a cloth infesting chamber, which was left on the ears overnight and then removed. The infesting chamber was made by sewing a 9 by 8 inch piece of muslin cloth into a sleeve and attaching draw strings at both ends (a zipper can be used on the outer or distal end instead of a draw string). A circular piece of Saran cloth 3 inches in diameter with holes for the ears was sewn inside the sleeve about one inch from the proximal end. The bag was placed over the rabbit's ears and secured by tying the draw strings under the neck.

A collar, made from a 10 by 10 inch piece of masonite, was used to prevent the rabbit from scratching the ticks from its ears. A circle 3 inches in diameter was marked in the center of the masonite. Then the board was cut in half, the circle was cut out for the neck, and the halves were joined by two 1 by 4 inch pieces of masonite and six ⅛ inch bolts ½ inch in length. This made the collar easy to attach and remove.

Engorged larvae were recovered in a metal pan placed under the hardware cloth cage in which the host rabbit was placed. A newspaper was placed in the bottom of the pan. Cheesecloth, stretched tightly on a wooden frame above the newspaper, helped prevent the engorged larvae from falling into water and urine that collected in the pan.

Engorged larvae were placed in rearing tubes previously described. In the first series of tests conducted with engorged larvae, three hundred larvae were divided into six tubes. One tube was held at each of the following combinations of relative humidity and temperature: 90% R.H. and 70° F., 80% R.H. and 70° F., 90% R.H. and 80° F., 80% R.H. and 80° F., 90% R.H. and 90° F., and 80% R.H. and 90° F. Other engorged larvae were held at 90% R.H. and 80° F. until a second test was set up using 100% R.H. and 90° F., and 100% R.H. and 80° F. as the variable conditions. Following this test engorged larvae were held at 100% R.H. and 80° F. The ticks were observed daily, and when molting began the number of nymphs was counted daily. Sometimes the number molting could not be determined without removing them from the tube. When 20 or more larvae had molted in the tube, the nymphs were removed.

Nymphs were fed both on the ears and belly of the rabbit. Those fed on the ears were confined in a plastic cage. The cage was made by rolling a 7 by 5 inch sheet of plastic into a cylinder one and ¾ inches in diameter,

stapled at the side and flanged at one end by cutting ½ inch slits ½ inch apart around the cylinder and bending the cut edge outward. A circular piece of Saran cloth 2¾ inches in diameter with holes for the ears was stapled to the flanged end. The cage was then placed on the rabbit's ears and secured by a tarpaulin strap (three inch wide adhesive tape can be used instead of the tarpaulin strap). A masonite collar previously described was placed on the rabbit to prevent it from scratching the cage. The nymphs were brushed into the cage, and the open end was covered with Saran cloth held in place by a plastic ring.

Some nymphs were fed in cages taped to the belly of the host rabbit. These cages were similar to those described by Jellison and Philips (1933). Tops of plastic mustard dispensers were used for making the cages. The ring of the cage was tightly fitted into a round hole toward one end of a 3 inch wide adhesive tape band of sufficient length to form an overlapping girdle on the rabbit. The threaded portion of the ring projected above the nonadhesive surface. The nonadhesive surface of a short band with a slightly smaller hole in its center was applied to the adhesive surface of the long piece of tape so that the holes matched and the under surface of the plastic ring was covered. The host rabbit was prepared for infesting by clipping an area on the belly considerably larger than that to be covered by the cage. The completed girdle was secured to the animal with the cage over the denuded belly area. The long end was passed around the body and overlapped. The margins of the girdle were reinforced by narrow strips of adhesive tape wrapped once or twice around the animal. A round hole was cut in the cap of the cage and covered by Saran cloth. The ticks were placed in the cage and the cap screwed on.

Engorged nymphs were removed from the cages as they fell from the host. Neither method was entirely satisfactory as only 10 to 20 engorged nymphs were recovered from 50 flat nymphs applied to each host.

Engorged nymphs were placed in rearing tubes. Twenty or more ticks were subjected to each of the following relative humidity and temprature combinations: 90% R.H. and 80° F., 80% R.H. and 80° F., 90% R.H. and 90° F., and 80% R.H. and 90° F. Seven ticks were placed in a 100% R.H. and 90° F. chamber. These ticks were observed daily. As molting began the number of adults was counted. Because of low numbers per tube it was not necessary to remove the adults.

The adult females engorged in cages, previously described, taped to the belly of the rabbit.

RESULTS AND DISCUSSION

Seasonal occurrence: Black-legged ticks were collected from dogs in Madison County, Arkansas. Only engorged females were taken. Usually the same dogs were examined on each collection. The ticks usually attach in the head and neck region, rarely to other parts of the body. The collection data, presented in Table I, indicate that adult ticks are present in the field at least from November to May, with a period of greatest abundance in February and March.

TABLE I. Summary of collections of engorged adult female black-legged tick from dogs in Madison County, Arkansas, 1956-57

Collection date	No. dogs examined	No. eng. females collected	Collection date	No. dogs examined	No. eng. females collected
Nov. 8, 1956	....*	8	Mar. 11, 1957	25	1
Nov. 10, 1956	....	8	Mar. 19, 1957	25	16
Dec. 10, 1956	....	1	Mar. 26, 1957	25	20
Jan. 8, 1957	18	9	Apr. 9, 1957	15	2
Feb. 8, 1957	25	16	Apr. 30, 1957	8	1
Feb. 21, 1957	25	8	May 10, 1957	15	0
Feb. 26, 1957	25	23			

* Number was not recorded.

Little is known about the seasonal occurrence of immature stages in Arkansas. As no collections were made for immature stages in this study, the only collection records available were unpublished records taken by Dr. J. L. Lancaster, Jr., of the Department of Entomology, University of Arkansas. Dr. Lancaster collected larvae in April and May, 1953, and nymphs in April, May and July, 1953, from cottontail rabbits.

Preoviposition and oviposition: Engorged adult female black-legged ticks were collected from dogs and used in relative humidity and temperature tests. A total of 86 ticks were subjected to different relative humidity and temperature combinations. The effects on preoviposition and oviposition are summarized in Table II.

TABLE II. Preoviposition period at different relative humidity and temperature combinations, Fayetteville, Arkansas, 1956-57

Degrees Fahrenheit	Per cent R. H.	No. eng. females	No. ovip.	Average preovip. days
80	80	7	4	10.25
70	60	4	3	13.33
70	80	8	6	9.8
70	90	28	25	10.1
60	60	3	0	.....
60	80	8	7	15.28
60	90	28	22	19.1

A high relative humidity and moderate temperature are required for the development of the black-legged tick. The optimum combination for oviposition as found in this study was 90% R.H. and 70° F. The number of engorged females depositing normal sized egg masses was not different at 80% R.H. and 90% R.H. The three female ticks which oviposited at 60% R.H. and 70° F. deposited small egg masses, and oviposition was incomplete.

Relative humidity did not significantly affect the duration of the preoviposition period at 70° F., but the duration was significantly shortened

from an average of 19 days to 15 days when relative humidity was lowered from 90% to 80% and temperature held constant at 60° F.

Temperature affected the number of engorged females ovipositing. When the temperature was either raised to 80° F., or lowered to 60° F. from the more favorable 70° F., the number of engorged females depositing eggs was lowered. A higher relative humidity at 80° F. might have resulted in a larger number of engorged females depositing eggs, although no such tests were conducted.

The duration of the preoviposition period was not significantly different at 80° F. and 70° F., but it was significantly increased when the temperature was lowered from 70° F. to 60° F. This increase averaged from 5 to 9 days depending on the relative humidity. The fact that the duration of the preoviposition period is decreased when the temperature is raised from 60° F. to 70° F. but remains constant when the temperature is raised to 80° F. suggests that the optimum temperature is between 70° F. and 80° F.

Eggs: Egg masses were held at the relative humidity and temperature combinations at which they were deposited except for six. These six were transferred from 90% R.H. and 70° F. to 80% R.H. and 70° F. an average of 11 days after the female began ovipositing. The effects of relative humidity and temperature on the hatchability of eggs are summarized in Table III.

TABLE III. Incubation period at different relative humidity and temperature combinations, Fayetteville, Arkansas, 1956-57

Degrees Fahrenheit	Per cent R. H.	No. egg masses	No. with any hatching	Average inc. period (days)
80	80	4	0	.....
70	60	3	0	.....
70	80	6	5	54.5
70	90	19	19	48.1
60	80	5	1	135.0
60	90	22	21	84.6

Hatchability of eggs was greatly affected by relative humidity. When relative humidity was lowered below the apparent optimum of 90% the number hatching was lowered. Of the six masses transferred from 90% R.H. and 70° F. to 80% R.H. and 70° F., five masses began hatching, but only a few eggs hatched in each mass.

The duration of the incubation period was significantly decreased when relative humidity was increased from 80% to 90% and temperature held constant at 70° F.

Temperature is not as critical to eggs as relative humidity within the ranges tested. Temperatures of 70° F. and 60° F. were favorable for hatching. A rise in temperature to 80° F. prevented hatching as indicated in Table III. It should be noted that the egg masses at 80° F. were held at 80% R.H. and that very few eggs hatched in those masses held at 80% R.H. and 70° F.

The optimum temperature for incubation is probably near 70° F. The duration of the incubation period was significantly decreased when the temperature was raised from 60° F. to 70° F. No eggs at 80° F. hatched so it was not determined if the length of the period would be shorter or about the same as it was at 70° F.

Larvae: Flat, or unfed, larvae at 80% R.H. lived only a few days. It was observed that unengorged larvae at 90% R.H. and 60° F. lived longer than those at 90% R.H. and 70° F. Flat larvae remained alive in the laboratory 15 days to two and one-half months after hatching, then readily attached to a host rabbit. All host rabbits were confined to cages in an open air insectary. The larvae were fed between April 26 and October 23, 1957. A total of 2,441 engorged larvae were recovered. The average feeding period was 4.08 days. Larvae have engorged and dropped from the host in as short as three days and as long as seven days after application to the host.

TABLE IV. Summary of molting of black-legged tick larvae, Fayetteville, Arkansas, 1957

Degrees Fahrenheit	Per cent R. H.	No. eng. larvae	No. molting	Average no. days feeding to molting
90	100	23	20	22.25
90	90	50	1	28.00
90	80	48	0	.....
80	100	349	324	23.27
80	90	1085	672	31.65
80	80	52	0	.....
70	90	50	27	45.85
70	80	50	0	.....

Data presented in Table IV indicate that the most favorable combination is 100% R.H. and 80° F. The percentage of engorged larvae transforming to nymphs was significantly lowered when the relative humidity was lowered to 90 per cent and no molting occurred at 80% R.H. When the temperature was lowered to 70° F. from 80° F., the percentage of larvae transforming to nymphs was lowered although the decrease was not significant at the five per cent level of probability. There was a significant decrease in the number of larvae transforming to nymphs when the temperature was raised from 80° F. to 90° F. and relative humidity held constant at 90 percent, but when relative humidity was held constant at 100% and temperature was raised from 80° F. to 90° F., the decrease was not significant. The data at 100% R.H. and 90° F. are based on only 23 larvae but provide a good indication that engorged larvae can survive at a high temperature if adequate moisture is available.

Relative humidity and temperature affect the duration of the larval stage after feeding. The duration was significantly shortened when relative humidity was raised from 90 per cent to 100 per cent. The duration of the larval stage was significantly decreased when the temperature was raised from 70° F. to 80° F. A further increase in temperature from 80° F. to 90° F.

did not significantly decrease the duration. That the duration of the larval stage after feeding decreased when the temperature was raised from 70° F. to 80° F. and then remained about the same when the temperature was raised from 80° F. to 90° F. indicates the optimum temperature is between 80° F. and 90° F.

Nymphs: Nymphs were retained in the laboratory one month before being placed on a host rabbit. A total of 123 nymphs engorged and were recovered. The first nymphs were fed on July 25, 1957, and the last were fed on November 22, 1957. A total of ten different feedings was made during this period. The time required for nymphs to engorge and drop from the host ranged from three to nine days. The average was 5.21 days.

TABLE V. Summary of molting of black-legged tick nymphs, Fayetteville, Arkansas, 1957

Degrees Fahrenheit	Per cent R. H.	No. eng. nymphs	No. molting	Average no. days feeding to molting
90	100	7	2	25.00
90	90	29	4	55.00
90	80	20	0	.....
80	90	20	20	33.73
80	80	20	14	30.60

The humidity and temperature conditions most favorable for survival of engorged nymphs, as indicated by data presented in Table V, are 90% R.H. and 80° F. All engorged nymphs subjected to these conditions completed molting. Relative humidity affected survival at 90° F., but had less effect at 80° F. A rise in temperature from 80° F. to 90° F. greatly reduced the number of nymphs transforming to adults.

Relative humidity affected the duration of the nymphal stage after feeding. An increase in relative humidity at 90° F. shortened the period, but at 80° F. relative humidity had no significant effect. Only two temperature comparisons were made. Although the data presented in Table V indicate the duration of the nymphal stage after feeding was increased when the temperature was raised from 80° F. to 90° F., it was difficult to determine the exact effect because of the low survival at 90° F.

Small numbers of nymphs were used in these tests but they do give an indication of the effect of temperature and relative humidity.

Adults: Adult ticks were retained in the laboratory from 17 days to two and one-half months before being fed on a host rabbit. Four females and four males were applied to a host on November 22, 1957. One female engorged and dropped from the host in 8 days. The other three engorged and fell on the ninth day. On November 27, 1957, seven females and six males were applied to the host rabbit. Only three of the females attached and completely engorged, all dropping from the host nine days after application. The average feeding period for adult females is 8.86 days. Six of seven females that completely engorged and dropped from the host when placed at 90% R.H. and 70° F. began ovipositing in an average of 16.16 days.

Mating was observed two days after the ticks were applied to the host. Three pairs continued to copulate after the female had fallen from the host. One female and male were observed mating prior to being placed on a host. The pair remained in copulation for five days. The male was then removed and the female was placed on a host in the absence of males. She attached and became about three-fourths engorged in 14 days. On the 15th day, however, she lost most of her engorgement. Death occurred on the 16th day.

SUMMARY

Adult black-legged ticks are present from November to May in Arkansas, while immature stages are probably present from early March until October. Temperature requirements of the black-legged tick influence its seasonal occurrence. The optimum temperature for adults is about 70° F. The mean maximum temperature at Fayetteville, Arkansas, does not exceed 77.5° F. during the months the adults are present.

The black-legged tick cannot survive if the relative humidity is below 80 per cent. Apparently from 90 to 100 per cent relative humidity is favorable for development. The optimum temperature for engorged females and eggs is near 70° F., while the optimum for larvae and nymphs is about 80° F.

The period of development under the most favorable laboratory conditions averaged 132 days which included 10 days for preoviposition, 48 days for incubation, 4 days for larval feeding period, 23 days for the duration of the larval stage after feeding, 5 days for the nymphal feeding period, 33 days for the duration of the nymphal stage after feeding, and 9 days for the adult feeding period. However, one generation a year is probably normal, as considerable time will be required for unfed larvae, nymphs and adults to find a host.

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FOURTH ANNUAL INSECT PHOTOGRAPHIC SALON

The Pacific Branch of the Entomological Society of America announces the fourth annual insect photographic salon to be held in conjunction with its meeting in Sacramento, 23-25 June 1959. Photographs will be judged in three categories: monochrome, color transparency, and color transparency sequence. Deadline for all entries is 16 June 1959. Entry blanks may be obtained from Dr. E. S. Ross, California Academy of Sciences, Golden Gate Park, San Francisco 18, California.

SYNONYMY OF THE GENERA *RHYACOBATES* ESAKI 1923 AND *ESAKOBATES* LUNDBLAD 1934, AND A DESCRIPTION OF A NEW SPECIES OF *RHYACOBATES* FROM CHINA (Hemiptera: Gerridae)[1]

HERBERT B. HUNGERFORD AND RYUICHI MATSUDA

In our revisional study of the Gerridae of the World we have found it necessary to propose some new generic names and unfortunately to reduce some genera to synonymy.

Dr. Esaki described the genus *Rhyacobates* for his new species *R. takahashii* from Formosa, in 1923 (Philippine Journal of Science, 22:387-391, plate 1), and Dr. Lundblad described the genus *Esakobates* for his new species *E. svenhedini* from northeastern Szechuan, China, in 1934 (Arkiv för Zoologi, 27A, no. 14: 22-26). These were monotypic when they were proposed, and the females appeared to us to be generically different. Then Hungerford described *Esakobates lundbladi* from Tien Mu Shan, China, in 1957, when Dr. Lundblad informed him that the species in question was not the winged form of his *E. svenhedini*.

Recently we discovered another new species from China and are now convinced that the differences in abdominal structure of the females in these four species are not generic but specific differences and that all four species should be assigned to the same genus. Since *Rhyacobates* is the older name, *Esakobates* Lundblad becomes a synonym of *Rhyacobates* Esaki. In all four species the females are larger than the males and more readily recognized. The abdominal segments in the females are not withdrawn into the thoracic cavity as in the females of *Potamometroides* Hungerford, and the hind femur is at least two and a half times as long as the tibia, instead of less than twice as long, as it is in *Potamometroides*. The males in *Rhyacobates* are very similar to those in *Heterobates*, but the generic differences we believe are most easily seen in the females. *Potamometroides* is known only from Madagascar, *Rhyacobates* from China and Formosa, and *Heterobates* from Nepal, northern India, and Turkestan.

Rhyacobates chinensis sp. nov.
(Pl. I, Pl. II, figs. 1, 3)

Size: Apterous male 6.4 mm. long; width across head 1.16 mm.; width across mesoacetabula 1.93 mm. Apterous female 8.0 mm. long; width across head 1.38 mm.; width across mesoacetabula 2.84 mm.

Color: Body black, overlain with silvery pubescence. Antennae dark brown. Labrum embrowned. Clypeus black. Vertex with a large black spot which narrowly bifurcates posteriorly. Pronotum with a large triangular brown spot. Mesonotum with a longitudinal brown band that may extend onto metanotum or even broaden on first abdominal tergite. Margin of

[1] Contribution No. 1013 from the Department of Entomology, University of Kansas. This paper is a by-product of a project aided by a grant from the National Science Foundation.

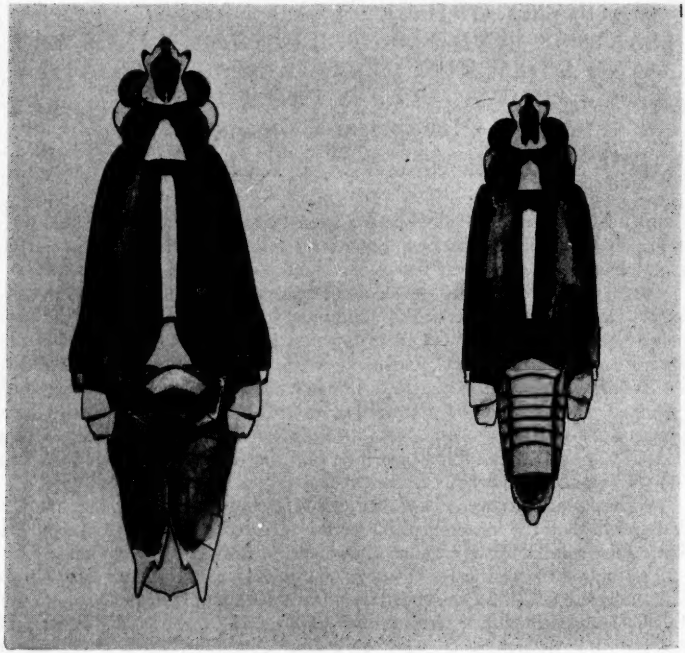

PLATE I
Rhyacobates chinensis Hungerford and Matsuda. Left, female; right, male.

connexivum brown in female. Prosternum, legs and distal ends of acetabula light brown. Mesosternum with a median, elongate, subtriangular, brown spot.

Structural characteristics: Relative lengths of antennal segments of male: 1st: 2nd: 3rd: 4th:: 160: 42: 48: 36; of a female: 180: 47: 52: 40. Head longer than pronotum in apterous forms. Beak short and stout, not reaching mesosternum.

TABLE I. Relative lengths of leg segments of a male.

	Femur	Tibia	1st tarsal segment	2nd tarsal segment	Total tarsal length
Front leg	165	132	46	30	76
Middle leg	490	255	?	?	?
Hind leg	500	150	4.7	9.3	14

Distal projection of front tibia more prominent in female than in male. Distal half of female abdomen curved upward. Connexiva erect on first two

segments, converging along dorsal mid-line of third through sixtth segments. Last abdominal segment (seventh abdominal) of female more or less tubelike, ventrally as long as three preceding segments together, deeply cleft dorsally, telescoping eighth and ninth segments within; rear margin of the tube with a projection above at end of each connexivum, laterad of which is a longer, obliquely directed protuberance; median ventral projection slender and sharp, sometimes continued as a low, longitudinal carina on ventral surface of the segment. Male paramere as shown in fig. 1.

Comparative notes: The female of this species has five apical projections instead of three as in *R. takahashii* Esaki.

Location of types: The male holotype, female allotype, four male and

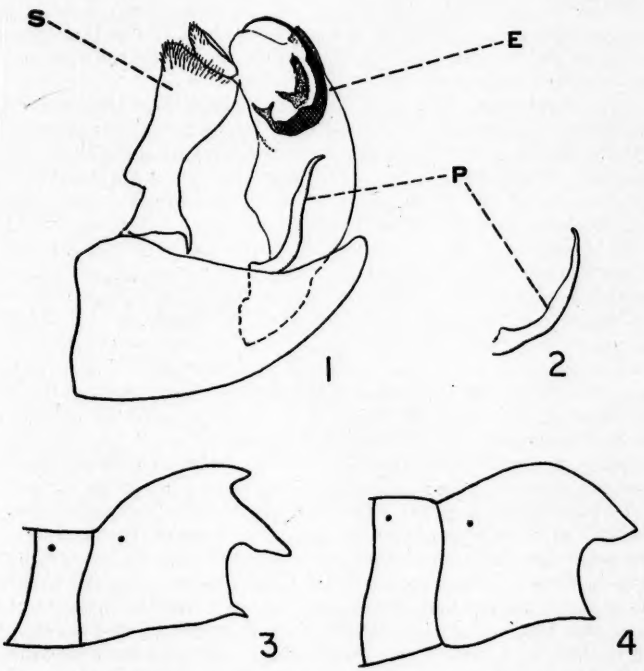

PLATE II

Fig. 1. Lateral view of male ninth segment of *Rhyacobates chinensis* Hungerford and Matsuda. S=suranal plate, E=endosoma, P=paramere. Fig. 2. Paramere of *Rhyacobates takahashii* Esaki. Fig. 3. Lateral view of female seventh abdominal segment of *Rhyacobates chinensis* Hungerford and Matsuda. Fig. 4. Lateral view of female seventh abdominal segment of *Rhyacobates takahashii* Esaki.

five female paratypes from Djalantun, Great Khingan Mountains, China, collected in June, 1938 by M. Weymarn are preserved in the Snow Entomological Museum, University of Kansas.

BOOK REVIEW

The Tarantula, by William J. Baerg. vii + 1-88, 19 illustrations. University of Kansas Press, Lawrence, Kansas. Publication date: August 21, 1958. Price $3.00.

This readable little book is written by an expert on tarantulas. Dr. Baerg (Ph.D., Cornell University), now Emeritus Professor of Entomology at the University of Arkansas, has made tarantulas one of his interests for thirty-five years. And, to quote Dr. Baerg regarding the tarantula (page 1): "Since its life-history may require at least twenty-four years to complete, the subject is not taken up by many researchers. In fact I can perhaps claim to be the only one who has followed the development of the trantula from infancy to death of old age."

A fellowship granted by the John Simon Guggenheim Memorial Foundation made it financially possible for Dr. Baerg to do some of the research for this book. Dr. Baerg first began studying tarantulas at the University of Arkansas, but this interest has taken him throughout the southwestern United States and into Mexico, Central America, and the Carribean region. In this book we learn of the distribution of tarantulas, largest of the spiders. In the United States there are about thirty species distributed throughout the southwestern states. They are numerous in many parts of the tropics.

Other headings are: Life of the Female Tarantula, Life of the Male, The Mating Act, and under Natural Enemies of Tarantulas are mentioned the large *Pepsis* wasps, or Tarantula Hawks, the mongoose, introduced into Puerto Rico, and a large dipterous or fly parasite that in its maggot stage lives in the body of the tarantula, and is "identified as belonging probably to the family *Apioceridae.*" Dr. Baerg states "The tarantula is probably its own most important enemy," being cannibalistic.

Under the title: How Poisonous are Tarantulas?, Dr. Baerg describes a number of tests conducted on white rats, guinea pigs and on himself. In all, he observed at least thirty-five different kinds of tarantulas, and for twenty-six of them he made poison tests. The effects of the tarantula's bite were sometimes fatal to the white rats and guinea pigs. As for himself, Dr. Baerg concludes: "All the species in the United States, as far as I have been able to determine, are harmless to man. Likewise harmless are most of the species that I have studied in Mexico, Central America, and Trinidad. The bite of these is as painful as a couple of pin stabs and has essentially the same effect." Moreover, he found that our tarantulas are generally quite reluctant to bite. With all this in its favor, it is no wonder that this long-lived handsome arthropod is becoming more and more a popular pet.

Dr. Baerg is to be thanked for writing so attractive and authentic a book, not lacking in humor, and we hope that it will have a wide circulation.—FRANCIS X. WILLIAMS, Associate Curator of Entomology, San Diego Natural History Museum.

A NEW GENUS OF BOMBYLIIDAE (Diptera)[1]

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This new genus belonging in the subfamily Exoprosopinae is described at this time to permit its use in a key and discussion of this subfamily to be published shortly.

Cyananthrax new genus

Diagnosis: The genus is distinguished from its relatives by the broad but stalked wings with reduced axillary and anal cells and alulae; vesture of the body and head of sparse hairs and a few slender, hairlike scales; two submarginal and four posterior cells; third antennal segment wtihout style but with short conical portion, in proportion to styliform part as 1:3.

Head slightly broader than thorax; length of occiput behind eye about equal to first two segments of antennae, deeply bilobate; eyes separated by

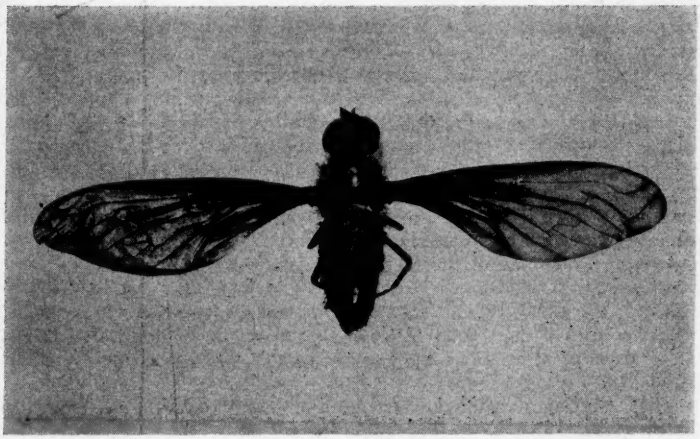

Fig. 1. *Cyananthrax cyanopterus* (Wied.)

about two and one-half times width of ocellar tubercle in both sexes; hind margin of eye deeply indented, the bisecting line extending among facets of eye for about length of first antennal segment; ocelli near vertex; front with a shallow depression midway between ocelli and antennae; face conic, protruding about the length of antennae beyond eyes and ending in a dense tuft of stiff hair; genae narrowly protruding, the furrow shallow; proboscis projecting slightly beyond buccal cavity; palpi slender, sparsely hairy, about as long as labella, apparently one segmented; antennae separated by about

[1] Contribution No. 719, Kansas Agricultural Experiment Station, Manhattan. The research of which this is a section is supported in part by National Science Foundation grant G4451.

length of third segment, first segment nearly three times as long as second, which is about as long as broad, both densely hairy; third segment short, conical, with a styleform prolongation three times length of basal part and ending in a small conic portion apparently not separated from rest of segment; vesture of head of sparse stiff hairs and a few short curved ones.

Body slender, shining, clothed with sparse, stiff hairs and a few slender, short curved ones on dorsum; humeral calli strongly developed; three or four postalar and prealar bristles, six slender marginal bristles and a few long delicate hairs on scutellum; propleura hairy; mesopleura and sternopleura sparsely hairy, metapleura with a fan-shaped tuft of hair in front of haltere; pteropleura and hypopleura bare.

Legs rather short, with appressed scales; front legs without spines, tarsi slender, with a few fine hairs, the claws one-third size of those of second and third pairs; second and third pairs of legs with usual spines on femora, tibiae and tarsi; claws with a blunt tooth at base about one-fourth length of claw.

Abdomen slender, shining, with sparse long hair above and below; seven visible segments, the last almost as long as the second; male genitalia retracted, asymmetrically placed; female ovipositor with a terminal circlet of hooked spines.

Wings club-shaped and stalked, broadest beyond the middle; thickly studded with minute microtrichia which are larger than in most Exoprosopinae; r-m crossvein at end of basal third of discal cell, $R_2 + 3$ arising near or opposite it at right angles to longitudinal vein; R_4 bearing a stump of varying length at basal bend in specimens seen; two submarginal cells; first basal and first posterior cells of about equal width throughout their lengths; discal cell narrow at base, considerably expanded near apex; a stump of a vein in third posterior cell; contact of discal and fourth posterior cell punctiform; base of fourth posterior cell about as long as r-m crossvein; anal and axillary cells subequal in greatest width, the latter much reduced; anal cell at edge of wing about as wide as length of r-m crossvein, narrower back a short distance from edge of wing; alulae much reduced, a sparse fringe of narrow scales present; basal hook small. Knob of haltere large, oval.

Type species of genus and only included species, *Anthrax cyanoptera* Wiedemann, 1830.

This genus is similar in body characters and head to *Hyperalonia* (type *morio* Fabr.), which also lacks the scales on head and body, characteristic of most Exoprosopinae. The wing, however, is totally different in shape and venation. The shape of the wing of *Cyananthrax* is like that of *Mancia* Coquillett, but the venational characteristics of the wings and the vesture of the two are totally different.

The type species has striking blue-black wings and a shiny black body set off by a collar of orange-red pile (fig. 1). The original specimen was from Mexico. It has been recorded (Osten Sacken, 1886; Williston, 1901) from Tepetlapa and Palo Blanco in Guerrero, Mexico.

Additional Mexican specimens have been seen from Guadalajara; Coapa, D.F., Aug. 29, 1922 (E. G. Smyth); Chapala, Jalisco, Sept. 11, 1938 (L. J. Lipovsky); and Morelia, Michoacan, Sept. 7, 1937 (L. J. Lipovsky).

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PREY RECORDS FOR SOME MIDWESTERN AND SOUTHWESTERN SPIDER WASPS (Hymenoptera: Pompilidae)

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Biological information on wasps as thinly distributed in nature as Pompilidae is hard to come by, but progress in this field in the past decade has been heartening. The notes presented here consist merely of prey records and in some cases notes on habitat and manner of prey carriage. All of the species treated are poorly known biologically, and for six of the ten species no prey records have previously been published. I am indebted to Dr. W. J. Gertsch, of the American Museum of Natural History, New York, for determining the spiders.

Cryptocheilus attenuatum Banks

In November, 1955, Dr. L. O. Warren, of the University of Arkansas, sent me a specimen of this species which he took in Chicot Co., Arkansas, during October of that year. The wasp was carrying a lycosid spider, an immature *Lycosa antelucana* Montgomery. Townes (1957) records a Kansas specimen taken with an immature *Lycosa* sp.

Cryptocheilus idoneum birkmanni Banks

On June 1, 1951, I found a female of this species near Lytle, Atascosa Co., Texas, dragging a spider backward along a sandy road. The spider, a female *Lycosa tigana* Gertsch & Wallace, was being held by the anterior end, probably by the chelicerae.

Ageniella (*Leucophrus*) *fulgifrons* (Cresson)

On June 25, 1950, Mr. T. L. Harvey, of the Ft. Hays Experiment Station, Kansas, took a specimen of this uncommon species with a spider, on the campus of Kansas State College, Manhattan. The spider, a female *Phidippus audax* Hentz (Salticidae), had all the legs cut off at the coxae.

Ageniella (*Nemagenia*) *longula* (Cresson)

On August 30, 1951, I encountered a female of this species on the campus of Kansas State College, carrying an immature *Lycosa* sp. along a sidewalk. All the legs of the spider had been amputated at the base.

Ageniella (*Ageniella*) *evansi* Townes

One female in the type series of this species was taken by the writer with an immature *Lycosa* sp. (Townes, 1957); all the legs of this spider had been amputated. I have seeen one additional specimen of this species with its prey, in this case a penultimate instar male *Tarentula kochi* Keyserling (Lycosidae), again with all legs amputated. This specimen was taken in the Graham Mts. of Arizona, Aug. 15, 1933, and is in the California Academy of Sciences collection.

Agenioideus (*Ridestus*) *biedermani* (Banks)

On May 9, 1958, Dr. C. S. Lin took a female of this species at Harlingen, Texas, with a male *Loxosceles devius* Gertsch & Mulaik (Scytodidae). The wasp was walking up a clay bank backward, dragging the spider sideways by one of the hind legs.

Pompilus (*Ammosphex*) *angularis* (Banks)

On Aug. 4, 1954, my wife and I took a female of this species near San Diego, California with a female *Pellenes* sp. (Salticidae). The wasp was carrying the spider backward over the top of some low weeds growing along the roadside, grasping the spider near the petiole in such a way that its body was perpendicular to that of the wasp. Another specimen of this species, from Rainbow Lodge, Colorado, is pinned with an immature *Xysticus* sp. (Thomisidae); this specimen is in the Cornell University collection, and bears no collector's name.

Pompilus (*Arachnospila*) *fumipennis eureka* (Banks)

I have seen a specimen of this form from Pt. Reyes, California, collected by J. C. Downey on May 30, 1956, pinned with a female *Tarentula kochi* Keyserling (Lycosidae). This form is also recorded as preying upon the lycosid genera *Lycosa* and *Trochosa* (Evans, 1951).

Aporinellus completus Banks

In the collection of the University of California at Davis there is a specimen of this species from Sierraville, California, taken Aug. 20, 1956, by E. I. Schlinger, pinned with a female *Pellenes oregonensis* Peckham (Salticidae). There are two earlier records of this species using Salticidae (Evans, 1951).

Aporinellus bridwelli Evans

On June 22, 1956, I collected a female of this species near Riviera, Texas, with a female *Oxyopes helius* Chamberlin (Oxopidae). The wasp was carrying the spider backward up a sand bank, grasping it near the petiole in the manner of most Pompilini.

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A STUDY OF THE MIDGUT EPITHELIUM OF FIVE WATERBUGS (Hemiptera: Cryptocerata)

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The present study was originally undertaken in an attempt to determine whether or not the food habits of the family Corixidae, which are unique among the waterbugs, are reflected in the structure and activity of the midgut epithelium. While this study was in progress, it was discovered that Dr. Margaret C. Parsons of the Harvard Biological Laboratories was engaged in similar research. An exchange of ideas and materials revealed that, while the material employed was virtually the same, the methods of study had been quite different. Dr. Parsons had approached the problem from a descriptive standpoint, while the author had employed a quantitative approach. This coincidence provided a most unusual opportunity to compare the results derived from different approaches to the same problem. Because of the close relationship between these two studies and because of the excellence of the study made by Dr. Parsons, the reader is referred to her paper for a detailed description of the problems involved. The present study will be restricted to those aspects of the problem which are primarily quantitative.

The material used was prepared in the following manner. Numbers of four waterbugs, *Belostoma flumineum* (Say), *Ranatra fusca* P.B., *Notonecta undulata* Say, and *Hesperocorixa escheri* (Heer), were collected from local ponds and isolated in individual aquaria without food for a minimum of 60 hours. This period was generally long enough to leave the forward portion of the midgut free of food. The insects were then termed "starved." They were allowed to feed for a specified period of time, two hours in the case of the predacious forms, and six hours in the case of the corixids, which are much slower feeders. Specimens were then taken for dissection at the following intervals: immediately after feeding, four, eight, twelve, twenty-four, thirty-six, and forty-eight hours after the cessation of feeding. Each insect was killed and the entire gut removed and fixed. Carnoy's fixative was used, supplemented in some cases with Kahle's or Bouin's when comparative material was desired. The paraffin embedding method was employed, and sections were cut seven microns in thickness. Mallory's triple stain and Short's haemotoxylin and acid fuchsin were used on alternate slides. The fifth insect, *Pelocoris femoratus* P.B. does not occur in the Topeka area. The material employed in this study was made available by Dr. Parsons. The preparation of the material was virtually identical with that of the other four insects. Held's and Bouin's fixatives were used with Mallory's triple stain and Delafield's haemotoxylin and eosin. Because of the methods used to analyze the data, these slight differences in preparation do not affect the results of the study. In all cases the sections used in this study were taken from the anterior portion of the midgut, designated by Parsons as Midgut I.

The histological and cytological picture found in the insect midgut is

often confusing because of the intense activity which occurs during digestion. Studies of these processes have been made in several insects and are reviewed in some detail by Parsons (in press). The lack of agreement among the various authors is conspicuous. Because of this an attempt is made in the present study to bypass subjective description and to find characters which can be measured more or less precisely, subjecting the results to statistical analysis to remove, as much as possible, bias on the part of the author. Sutton's description of the midgut epithelium of *Corixa* can be used as a point of departure. She stated (Sutton, 1951, p. 481), "The cells of the mesenteron are always grouped in 'cell nests' resting on the basement membrane which also provides for each nest a theca extending to one third of the distance from the base to the free cell edge. At the base of each nest is found a small group of deeply staining cells, whose nuclei are frequently seen dividing." In the present study these deeply staining cells will be called "regenerative cells." The walls of the cell nest will be called "villiform ridges," and the large cells which make up these ridges will be called "mature cells." As will be seen, the histological picture varies considerably from insect to insect, and, in some cases, with the presence or absence of food in the gut.

The main variables which affect the structure and appearance of the midgut epithelium are these: (1) the presence of food in the gut; (2) the length of time that this food has been present; and (3) the type of insect involved. All of these can be measured and are fairly easily controlled. The characteristics of the gut which are affected by these variables are more numerous and more difficult to measure. Of the characteristics used by other investigators only a few can be accurately measured. Parsons has given a description of the histological and cytological details of the changes caused by these variables. Most of these changes, however, are difficult if not impossible to treat quantitatively. For the purpose of this study then, three characteristics which could be easily measured were chosen: (1) the height of the villiform ridge from the tip of the tallest cells to the bottom of the cell nest; (2) the number of mature cells in a median section of any one cell nest; and (3) the number of regenerative cells in a median section of any one cell nest. These three measurements were made for ten different cell nests in each specimen. No more than three cell nests were measured in any one section, the selection being made as randomly as possible. The highest and lowest measurements for each character were discarded and the arithmetic mean taken for the eight remaining measurements. Table I shows the distribution of these means for each character and the number of specimens for each stage of feeding period. Inspection of this table will show that fluctuations in these measurements do occur with time and that the fluctuations are much larger in some cases than in others. Whether or not these fluctuations are related to the feeding period, and whether the differences are large enough to be meaningful requires a statistical analysis. The number of specimens in each of the eight feeding periods is necessarily small because of the immense amount of time involved in the preparation of each specimen. In order to increase the sample size the number of time classes was reduced to three as is shown in Table I. Inspection of these time

TABLE I. Means of measurements* and numbers of specimens for each period and time class for five species of waterbugs.

Time class	Feeding period	Notonecta A	Notonecta B	Notonecta C	Notonecta D	Belostoma A	Belostoma B	Belostoma C	Belostoma D	Pelocoris A	Pelocoris B	Pelocoris C	Pelocoris D
	Fed	14.4	7.6	8.2	2	41.0	19.6	11.2	3	33.1	9.8	6.1	2
I	4 hrs.	12.1	7.7	8.2	2	30.4	15.2	15.2	1	38.5	9.6	6.8	2
	8 hrs.	22.1	8.8	8.9	2	49.4	22.1	13.9	1	42.7	9.2	6.5	1
	12 hrs.	16.1	8.0	8.1	1	40.5	20.0	11.5	1	56.6	9.2	6.9	1
II	24 hrs.	16.0	9.0	9.1	1	43.4	19.0	10.0	1	59.3	7.2	6.4	1
	36 hrs.	26.8	10.0	9.7	1	42.1	16.7	10.3	1	51.8	7.5	6.6	1
III	48 hrs.	26.5	9.6	10.0	1	31.2	14.3	10.6	1	53.0	7.6	6.0	1
	Starved	30.1	10.9	9.8	3	34.4	19.2	11.8	4	49.2	8.8	5.9	3
		Ranatra A	Ranatra B	Ranatra C	Ranatra D	Hesperocorixa A	Hesperocorixa B	Hesperocorixa C	Hesperocorixa D				
	Fed	21.6	11.1	9.9	1	35.5	13.9	11.2	3				
I	4 hrs.	16.5	8.0	9.7	1	30.9	12.4	13.3	3				
	8 hrs.	23.3	9.8	10.0	1	28.4	12.4	10.9	3				
	12 hrs.	24.8	11.2	9.7	1	28.9	12.2	10.7	2				
II	24 hrs.	20.4	10.4	9.5	1	23.5	13.2	9.8	1				
	36 hrs.	39.9	10.6	10.4	1	37.7	14.1	9.9	2				
III	48 hrs.	49.4	16.6	10.7	1	35.6	13.3	10.4	2				
	Starved	41.7	11.7	10.6	3	36.4	13.4	11.4	4				

* The figures presented are means of all the measurements for each character for all specimens used in each feeding period.
"A" Indicates the height of the villiform ridge, in arbitrary units.
"B" Indicates the number of mature cells in any one cell nest.
"C" Indicates the number of immature or "regenerative" cells in any one cell nest.
"D" Indicates the number of individuals in each feeding period.

classes will show that if any cyclical variation occurs among these means, it will show up as difference between these time classes. An analysis of variance was then run for each of the three characters in each of the five insects. The mean squares were tested for significant differences, first for variance among the three time classes and then for variance between feeding periods within time classes. In addition to this, the coefficient of variation was calculated giving an estimate of the over-all variation of each character in each insect. The level of significance was set at $P = .01$. The results of these calculations are given in Table II. It should be noted that where there is a significant variation shown between time classes, this variation occurs over and above that occurring between feeding periods within time classes.*

Examination of Table II points out some interesting relationships. Looking first at the variation between time classes, it is immediately seen that there are two distinct groups. *Hesperocorixa* and *Belostoma* form one group which shows no significant variation in any of the three characters. *Notonecta* and *Pelocoris* form the second group in which significant variation is found for all three characters. *Ranatra* differs from either group, showing significant variation in the thickness of the epithelium but no such variation in the other two characters. Turning to the variation between feeding groups within the time classes, one is struck by the variation found in the epithelial thickness, which shows significant variation in all of the insects except *Pelocoris*. This situation can be accounted for when one considers that possibly three separate factors are acting together to affect the thickness of the epithelium. The first factor is the number of cells involved, esepcially of the mature cells, as these account for the largest portion of the thickness of the epithelium. The second factor is the size of these cells. As these cells become mature they grow in size, the largest cells being the ones usually considered to be involved in the process of secretion. The third factor is a purely mechanical one associated with the stretching of the epithelium and the pressure upon the cells caused by the presence of large amounts of food in the gut. In insects such as *Belostoma, Ranatra,* and *Notonecta,* which are often seen to engorge almost to the bursting point, this factor may be considerable. *Hesperocorixa* which is a continuous feeder, normally has the gut expanded with food at all times but rarely swollen and engorged like the other forms. Thus one might expect such stretching to be less in this insect. In *Belostoma* and *Hesperocorixa* the variation in epithelial thickness, while fluctuating between feeding periods, does not appear to be associated with the time classes and therefore not with any over-all cyclical change. This fluctuation in thickness can, however, be explained by the mechanical stretching and pressure which are caused by engorgement and peristaltic activity. Such an explanation is borne out by the difference in the coefficient of variation for thickness which is high for *Belostoma* (an intermittent feeder) and low for *Hesperocorixa* (a continuous feeder). In *Ranatra* there is evidence that the variation in epithelial thickness is related to the time

* In the analysis of variance the mean square of the variance between time classes is tested against the mean square of the variance between feeding periods within time classes. When the resulting figure is significant, it represents differences between time classes over and above variation between feeding periods within time classes.

TABLE II. Results of analysis of variance of three characters for five species of waterbugs.

Source of variation	Species	Thickness of epithelium	Number of mature cells	Number of regenerative cells
Variation between time classes	*Belostoma*	n.s.	n.s.	n.s.
	Hesperocorixa	n.s.	n.s.	n.s.
	Ranatra	**	n.s.	n.s.
	Notonecta	**	**	**
	Pelocoris	**	**	**
Variation between feeding periods within time classes	*Belostoma*	**	**	**
	Hesperocorixa	**	n.s.	n.s.
	Ranatra	**	**	n.s.
	Notonecta	**	n.s.	n.s.
	Pelocoris	n.s.	n.s.	n.s.
Coefficient of variation	*Belostoma*	13.6	18.4	16.1
	Hesperocorixa	8.5	13.2	15.8
	Ranatra	18.5	11.5	18.9
	Notonecta	26.8	20.9	20.4
	Pelocoris	9.7	0.7	14.6

** Indicates an F value at $P \leqq .01$.
n.s. Indicates a non-significant F value ($P > .01$).

classes, which would suggest that since there is no similar variation in the number of mature cells there is a cyclical change in the size of these cells. This in turn suggests some kind of cyclical apo-merocrine secretory process. *Ranatra,* like *Belostoma,* is an intermittent feeder and thus the mechanical stretching due to engorgement is also a factor. This is borne out by the large coefficient of variation for thickness shown by *Ranatra.* In the case of *Notonecta,* there is evidence that a fluctuation of the number of mature cells between time classes is one of the factors affecting epithelial thickness. This suggests that a cyclical, holocrine secretory process is involved. In addition to this *Notonecta* is an intermittent feeder and thus stretching is also a factor. The coefficient of variation for epithelial thickness, as might be expected, is high. Like *Notonecta, Pelocoris* shows definite evidence of a cyclic variation in the number of mature or secretory cells, suggesting some type of holocrine secretory activity. There is, however, no evidence of a significant variation in epithelial thickness within the feeding periods. Furthermore, the coefficient of variation is quite low. This might suggest that stretching of the epithelium is not a large factor in this case. It is possible that this insect may feed more frequently than the other predaceous forms, taking many small meals rather than a few during which it engorges heavily. To date, Parsons' observations on *Pelocoris* under laboratory conditions fail to confirm this hypothesis.

The fluctuation in the number of mature cells within time classes found in *Belostoma* and *Ranatra* can be explained when one considers the effect

of this mechanical stretching upon the villiform ridge type of structure found in these insects. When the epithelium is stretched, the effective diameter of these structures is increased without increasing the number of actual cells. Thus when a section of predetermined thickness is taken, the number of cells visible per cell nest will be decreased. This apparent decrease in the number of cells will be roughly proportional to the amount of stretching which occurs. This factor may be considerable in *Belostoma* and *Ranatra,* and yet not be significant in *Hesperocorixa* where stretching is a smaller factor or again in *Notonecta* where the villiform ridge type of structure is much less pronounced. This explanation can be used to account for the significant fluctuation, within the time classes, of the number of regenerative cells in *Belostoma,* which is often seen to attack prey even larger than itself and engorge for several hours.

When the results of this study are compared with those obtained by Dr. Parsons from her descriptive study, close correlations are found, and several of her conclusions are verified. She finds two morphological types of epithelium present. The Type I epithelium is characterized by a highly developed villiform ridge type of structure and is found in *Ranatra, Belostoma,* and *Hesperocorixa.* This type of epithelium is characterized by apo-merocrine secretory activity, which is related to the feeding cycle in *Ranatra* and *Belostoma* but not in *Hesperocorixa.* The thickness of the epithelium appears to fluctuate with the amount of food present. The Type II epithelium is characterized by poorly developed villiform ridges, which are entirely absent at times. In *Notonecta,* she finds a well developed holocrine secretory cycle which is related to feeding. In *Pelocoris,* however, while she finds evidence of holocrine secretion, she is unable to relate it to the feeding cycle. The apo-merocrine cycle which she reports for *Ranatra* is confirmed, but such a cycle cannot be demonstrated for *Belostoma.* It is possible that in *Belostoma* a weak cyclic trend might be covered up statistically by the large variation between feeding periods with time groups. Parsons reports an increase in the number of "blistered cells" at four and a half hours after feeding. Table I shows a sharp drop in epithelial thickness at this time followed by a sharp rise at eight hours. All of this, however, takes place within a single time class and thus does not show up in the over-all cycle.

The present study is also able to contribute the additional information that the holocrine secretory activity of *Pelocoris* is of a definitely cyclical nature even though the activity is less pronounced than in the case of *Notonecta.* This latter point is indicated by the low coefficient of variation in *Pelocoris* for epithelial thickness and the number of mature cells.

The close agreement of the results of these two independently conceived and executed studies shows clearly that, even in the case of such highly variable material as the midgut epithelium of an insect, a quantitative study, such as the one presented here, can not only confirm the results of a qualitative study, but yield additional information from the same material.

The author is indebted to Dr. Robert Sokal for his patient help in designing the analysis of variances which was used in this study, to Dr. Margaret Parsons for her loan of the *Pelocoris* material, and to Dr. Fred Lawson and Dr. Parsons for checking the manuscript.

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NOTES ON THE BIOLOGY OF *HESPERAPIS REGULARIS* (CRESSON) (Hymenoptera: Melittidae)

D. J. BURDICK[1] AND P. F. TORCHIO[2]

This investigation started with the discovery of numerous *Hesperapis regularis* (Cresson) adults in May 1955, by P. F. Torchio and D. W. Ribble, within a restricted area near the Arroyo Seco Campground, Monterey Co., California. During the ensuing years the authors have made observations on the general activity around the nesting area, the sleeping habits, burrow and cell construction, flower relationships, and mating attempts. In addition larvae were collected for study and comparisons made with the larval description of *H. ruficeps* (Ashmead) (Michener 1953).

The nesting site was on the east side of a small steep-sided canyon. The canyon floor was nearly flat and covered with an oak-grassland with chaparral along the wall. The nesting site lay at the base of the wall in an area of orange sandy soil which was only sparsely covered by grasses and *Eriodyction californicum*. Due to the steepness of the walls and orientation of the canyon, the sun did not reach the site until 7:50 a.m. on April 23 and 24, when the daily activity was studied. The major nectar source, *Chorizantha douglasi* and the pollen source, *Clarkia unguiculata,* were growing in large numbers on the wall and along the upper rim of the canyon.

Large numbers of the males were observed patrolling the nesting area, apparently searching for receptive females. This patrolling activity was noted to be dependent upon the presence of sunlight, for all flight stopped when the sun was hidden by a cloud and would resume when the sun emerged. Neither sex was found active in the morning before the sun reached the nesting site. The nesting and digging activities seemed to be dependent upon daily temperature changes, as throughout our observation the bees became progressively more active until the peak temperature of the day was reached and were less active as the temperature dropped.

Linsley and MacSwain (1958) found males of this species beginning to settle for sleep on various plant stems and in partially closed flowers of *Clarkia purpurea bivulnera*. The males under our observation spent the night in the ground. Females, presumably those without provisioning burrows, and some of the males started searching the area for open unused burrows or began construction of short burrows less than 3 cm. in depth in the afternoon from about one to five o'clock. When a satisfactory burrow

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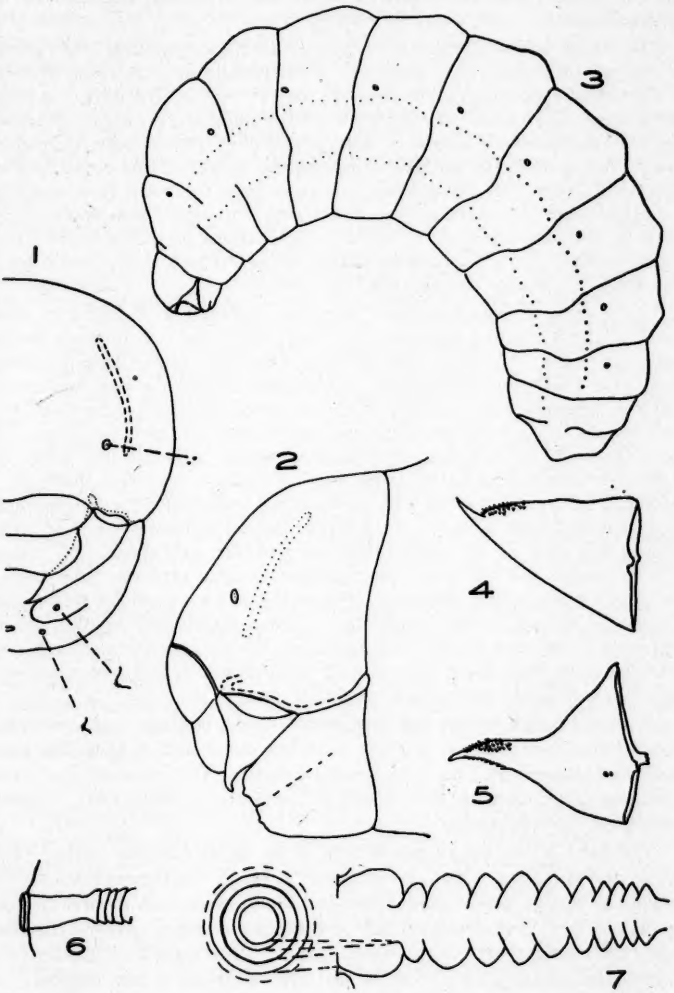
had been found or constructed, the entrance was filled with sand taken from within the burrow. This sand was pushed up by the head of the bee and formed a plug which protruded as a small mound. The mound was composed of irregular masses of weakly compacted sand which differed from the fine granular sand of the tumulus around the provisioning burrows. Those females with active burrows slept in them, plugging the entrance in the same manner as above. However, considerably more soil was moved as the cone of the tumulus was filled, thus forming a pyramid above the ground level.

On the basis of these observations, it appears that males of *H. regularis* sleep either on stems and flowers or within burrows in the ground. Linsley and MacSwain (1958) have indicated a similar activity in an undescribed species of *Hesperapis* found at Antioch, Contra Costa Co., California, in which the number of active males was larger than the flower sleeping population.

The first morning the males emerged from their sleeping burrows at 8:02 a.m., and by 8:20 a.m. they were flying in numbers. The first female was observed at 9:20 a.m., with her scopa laden with pollen. None of the five burrows under observation was opened before 10:00 a.m., and one was closed for the night at 6:00 p.m. and had not been reopened when the observations terminated forty hours later. During the morning and early afternoon, the males were found resting on the ground or taking nectar. Four females were observed digging burrows, the earliest starting time being 10:35 a.m.

The burrows were started with the removal of the dry sand grains from a chosen spot by use of the mandibles and legs. The female always entered the developing tunnel head first and, after a varying length of time that increased as the burrow lengthened, backed up to the entrance with a mass of sand held between the mesothoracic legs and the venter of the curled abdomen. She then threw the sand with a fast, backward and outward movement of her mesothoracic and metathoracic legs. This soil was very fine grained and eventually formed a circular tumulus around the opening. Because of the angle of entry of the burrow the tumulus was asymmetrical with its peak in line with the bees' entrance and its sides sloping down to the area above the entrance. The digging activity was interrupted by occasional 3 to 4 minute rest periods during which time the female stood in the entrance with only her head exposed. The length of time needed to construct a burrow was not ascertained.

We were unable to find any area of gregarious nesting, and all cells were well separated. In excavating cells of the previous year, only two were found closer together than 10 cm. The cylindrical cells were 9 to 16 cm. beneath the surface of the ground with a diameter of 4 to 7 mm. and a length of 15 to 19 mm. The position of the cells varied from nearly parallel to an angle of 30° from the ground surface. The unpolished walls of the cells were apparently formed by compressing the surrounding sand. The condition of the soil prevented the tracing of a complete burrow to its cell. But the data gathered indicate a single cell to a burrow, with the possibility



LARVA OF *Hesperapis regularis* (CRESSON)

Fig. 1. Dorsal view of head. Fig. 2. Lateral view of head. Fig. 3. Lateral view of prepupa. Fig. 4. Ventral view of mandible. Fig. 5. Inner view of mandible. Fig. 6. Lateral view of salivary opening and salivarium. Fig. 7. Lateral and cross-sectional views of spiracle.

that the female may occasionally use the same entrance but excavate a separate burrow.

The females were gathering pollen of *Clarkia unguiculata* from those flowers growing along the hillside above the nesting area. A single female was observed collecting pollen from the flower. She landed on the corolla and grasped the base of the pistil with her mandibles. Each mesothoracic leg was bent forward around a stamen and then pulled posteriorly and down. This moved the anthers alongside the scopae of the metathoracic legs, which were then moved back and away from the body, thus scraping the pollen from the anthers. The thoroughness of this action was greatly aided by the long hairs of the scopae. Comparisons of pollen taken from females at the nesting site and the pollen remains from the meconium with that of *Clarkia* further supports the host association.

One mating attempt was noted near the nesting spot at 1:30 p.m. The female had been sitting motionless on the ground for two minutes, while numerous males were flying over the area. One male dropped on her from two inches above and immediately grasped her around the pro- and mesothoracic segments with his legs. With his every attempted coition, the female would flip her abdomen up and extend her metathoracic legs away from her body. Six attempts were counted before the male flew away. A male and female were found in the mating position described above, in a rearing chamber at 8:00 a.m. This position was maintained for five minutes after their discovery, with one act of copulation noted, lasting for 48 seconds. During this interval, the female bent her abdomen downward and moved it in a circular motion, while her metathoracic legs kept reaching toward the genital region of her abdomen. The male had his mandibles spread and the wings slightly uplifted until the act was terminated by the female flipping her abdomen up twice in succession. Both the female and male had emerged from their pupal skins during the previous evening, so the wings were not sufficiently hardened for either to fly.

A total of nine larvae were examined. Three of these were preserved and the remainder reared, in order to obtain pupae and to check the field evidence that permitted the larva-adult association. The larvae were inactive C-shaped prepupae with the dorsum of the posterior abdominal segments resting on the meconium.

The food of the larva consists only of the inner contents of the pollen grain, and the exine is passed completely through the digestive tract. The triangular shaped pollen grain has a truncate lobe at each corner, and the apices of these lobes are dissolved so the inner contents may be digested. After the contents have been removed, the exine is passed on through the alimentary canal. This hollow shell, now translucent but retaining its original shape and color, is excreted and added to the meconium. The meconium fills one end of the cell and is composed of rows of irregularly shaped flakes that are made up of varying numbers of exines but only one to three grains in thickness. Because of the complex structure of the meconium and its equal size to the pollen ball, it is believed that the digestive tract is open throughout the larval stages.

Our laboratory notes show that the prepupae collected April 14 to 16, 1958, varied from 13 to 17 mm. in length and 5 to 7 mm. in diameter. The pupae formed between April 20 and 29, 1958, and varied from 7 to 11 mm. in length and 5 to 7 mm. in diameter. The pupal stage ranged from 5 to 13 days. The adults emerged between May 2 and 6, 1958, during the hours from midnight to 8:00 a.m., and all were able to fly 26 hours after their emergence. These adults ranged in length from 8.0 to 10.0 mm. and died within 48 hours after emergence under laboratory conditions.

DESCRIPTION OF LARVA

Larva moderately robust, with intersegmental lines conspicuous; lines between cephalic and caudal annulets of segments absent or nearly so, but posterior portions of each segment somewhat elevated on dorsum (fig. 3). Ventrolateral tubercles form a low rounded ridge beneath the spiracles.

Head capsule scarcely sclerotic, without setae. Marginal thickening of head capsule weak; epistomal suture present; dorsal longitudinal line of head capsule absent; parietal bands conspicuous. Antennae mere discs, not at all elevated; labroclypeal suture distinct; labrum spiculate laterally. Mandibles acutely pointed, a series of small teeth along lower margin near apex, the series along upper margin grading into the multidentate cusp; maxillae not clearly separated from labium except apically, not much bent inward, palpi broader than long; salivary opening small, slit-like, in a slight depression, its margin produced as a slight lip.

Spiracular atria without internal ridges or spines, produced above body surface, with distinct rim and peritreme; primary tracheal opening with collar.

In comparing this species with Michener's (1953) description of *H. ruficeps* (Ashmead) a number of differences were noted. In *H. regularis* the epistomal suture is present, the mandibles are more slender and the opening of the salivary gland is a slit encircled by a lip (fig. 6). The establishment of the taxonomic value of these characters must await the study of other species as the two now known are placed in separate subgenera (Michener *in* Muesebeck et al., 1951).

ACKNOWLEDGMENTS

We wish to thank Dr. P. D. Hurd, Jr., University of California, for the identification of the *Hesperapis* and Dr. Helen K. Sharsmith, University of California, for her identifications of pollen and nectar sources.

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IDENTIFICATION OF THE NYMPHS OF COMMON FAMILIES OF HEMIPTERA[1]

FRED A. LAWSON[2]

Discussions of insect development usually include a general statement to the effect that the nymphs of insects undergoing gradual metamorphosis resemble the adults in body form except for wings, reproductive organs, and related structures. Experience and observation have proved to the writer, however, that such a viewpoint cannot be taught literally in the identification of nymphal Hemiptera. Additional features in which the nymphs are *not* similar to the adults include the ocelli, number of segments in the antennae, and shape of body parts such as the pronotum. As a result, therefore, these structures have not been employed in the key which follows.

Certain general characteristics of the adults are equally applicable to the immatures, however. Among these are the minute hidden antennae of the water bugs, a short beak not extending beyond the front coxae as opposed to a longer one extending to or beyond the bases of the second legs, and the raptorial front legs of several families. Features which, understandably, are not used in adult classification are the various combinations of dorsal-abdominal gland openings. These occur singly or in pairs on the caudal margins of tergites three; three, four, and five; or four and five. The orifices of those with paired openings usually are located either within a pigmented area which includes a small amount of the next succeeding segment or on the edge of an elevated, sclerotized, often spinose, median caudal extension of the tergum. The various types of openings are illustrated in the plate following the key.

This key grew out of several years of teaching a course on immature insects. It has been tried and thoroughly criticized by a large number of students and by others interested in the subject. Their difficulties and suggestions have resulted in numerous improvements. Sincere appreciation is extended to all.

HEMIPTERA
Key to Nymphs of Selected Families

1a. Antennae shorter than head, usually located in a ventrolateral depression 2
1b. Antennae much longer than head, visible from above or from the side 7
2a. Prothorax very long; legs and body stick-like ..... NEPIDAE
2b. Prothorax short; legs and body not both stick-like 3
3a. Hind tarsi without claws 4
3b. Hind tarsi with claws 5
4a. Front tarsi with 2 claws each ..... NOTONECTIDAE
4b. Front tarsi without claws ..... CORIXIDAE

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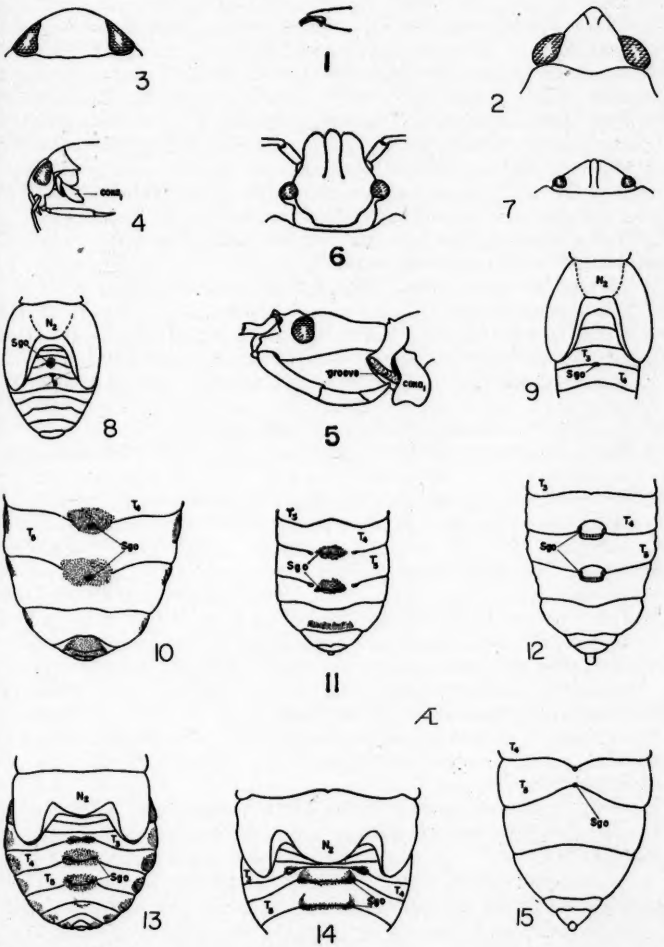

PLATE I

Fig. 1. Front tarsal claws of gerrid. Figs. 2 to 7. Heads, as follows: fig. 2, naucorid; fig. 3, belostomatid; fig. 4, saldid; fig. 5, reduviid; fig. 6, pentatomid; fig. 7, corimelaenid. Figs. 8 to 15. Dorsal abdominal scent gland openings, as follows: figs. 8 and 9, mirids; figs. 10 and 11, lygaeids; fig. 12, coreid; fig. 13, pentatomid; fig. 14, scutellerid; fig. 15, corizid.

ABBREVIATIONS: N_2—mesonotum; T_3, T_4, etc.—abdominal tergites; Sgo—scent gland openings.

5a. Eyes protruding; head not rounded in front (fig. 2); fore tarsi with claws 6
5b. Eyes not protruding (fig. 3); head smoothly rounded in front; fore tarsi without claws ..... NAUCORIDAE
6a. Head pointed in front (fig. 2); hind legs flat, fringed with long hairs ..... BELOSTOMATIDAE
6b. Head flat or concave in front; hind legs not fringed; body rough, warty, toad-shaped ..... GELASTOCORIDAE
7a. Head as long as entire thorax and very slender; legs long, hair-like; eyes small, on sides of head, halfway back HYDROMETRIDAE
7b. Head not as long as entire thorax 8
8a. Tarsal claws of front legs attached subapically (fig. 1) 9
8b. Tarsal claws of front legs attached apically 10
9a. Middle and hind coxae adjacent, both far removed from front coxae; beak 4 segmented, second very short ..... GERRIDAE
9b. Coxae spaced evenly on venter; beak 3 segmented ..... VELIIDAE
10a. Legs much longer than body and thread-like; body very long and slender (stick-like); last segment of antennae somewhat swollen ..... NEIDIDAE
10b. Legs, body, and antennae having different proportions 11
11a. Front femora very deep compared to length, in side view (almost triangular) 12
11b. Front femora long compared to depth, more or less tubular 13
12a. Body slender, minute in size; head pointed forward, with beak extended ..... ENICOCEPHALIDAE
12b. Body stout, deep; head pointed down, with beak turned back under ..... PHYMATIDAE
13a. Front femora long and cigar shaped, with dense fine hair and 4 or 5 evenly spaced long black hairs on ventral surface; front tibiae each with two long rows of tiny black spines on posterior surface ..... NABIDAE
13b. Front legs with different characteristics 14
14a. Beak short, often stout, never extending beyond front coxae (fig. 5) 15
14b. Body long, usually slender, extending to bases of middle legs or beyond (fig. 4) 19
15a. Body very wide and flat, with little depth compared to width 16
15b. Body much deeper compared to width, not notably flat 17
16a. Body segments with one, or parts of two, regular rows of warty bumps; hairs absent; legs widely spaced on venter ..... ARADIDAE
16b. Body segments without warty bumps; head, legs, antennae, and body with light covering of long, curved, recumbent hairs; legs spaced normally ..... CIMICIDAE
17a. Head elongate, tubular; tip of beak fits into a median groove in lower front surface of prosternum (fig. 5) ..... REDUVIIDAE
17b. Head transverse, flattened; beak not fitting into prosternal groove 18
18a. Beak extremely short (no longer than head), on minute insect (full grown nymph 3 mm.); middle coxae spaced farther apart than hind pair ..... ANTHOCORIDAE

18b. Beak longer than head, on larger insects; coxae spaced evenly ..... MIRIDAE

19a. Beak very slender, with 3 segments: first minute, second very long, and third from ⅓ to ½ as long as second (fig. 4) ..... SALDIDAE

19b. Beak heavier and with different proportions among the segments 20

20a. Pronotum with wide, plate-like lateral projections; body spinose, either with very long spines (single), or with 2 or more shorter spines (sometimes mixed length) arising from a common base (scolus) ..... TINGITIDAE

20b. Pronotum without plate-like lateral projections or (rarely) with a very narrow flange; body not spinose as above 21

21a. One set of dorsal abdominal gland openings, or none; those present minute, located medially on posterior margin of third abdominal segment and often located in a small pigmented area (figs. 8, 9) ..... MIRIDAE

21b. Two or three sets of dorsal abdominal gland openings, either circular or transverse, sometimes slit-like (figs. 10-15) 22

22a. With three sets of dorsal gland openings, on segments 3, 4, and 5 (figs. 13, 14) 23

22b. With two sets of dorsal gland openings (figs. 10-12, 15) 28

23a. Head 1.5-2 times wider than long, transverse, somewhat retracted into prothorax (fig. 7) 24

23b. Head as long as wide, or longer, and truncate or pointed (fig. 6) 25

24a. Body strongly arched on top; a single median sclerotized or pigmented area includes openings of all scent glands ..... CORIMELAENIDAE

24b. Body flat or nearly flat on top ..... CYDNIDAE

25a. First, and sometimes second and third, abdominal tergites reduced in center from crowding by enlarged mesonotum; first dorsal gland openings very far apart (fig. 14) ..... SCUTELLERIDAE

25b. First three abdominal tergites continuous across top, not crowded by mesonotum; first dorsal gland openings close together (fig. 13) 26

26a. Sclerite around first scent gland openings narrow and transverse, not over half the size of that around second and third openings (fig. 13) ..... PENTATOMIDAE

26b. Sclerites around all scent gland openings the same size (or absent) 27

27a. Head slender, black and elongate (neck-like); body relatively slender ..... (*Myodocha*) ..... LYGAEIDAE

27b. Head without neck-like modification; body stouter ..... PYRRHOCORIDAE

28a. Dorsal gland openings large, on transverse, usually pigmented and/or spinose swellings in median caudal areas of respective segments (fig. 12) ..... COREIDAE

28b. Dorsal gland openings small to minute; truncated swellings not present but a flat pigmented area may surround openings 29

29a. Dorsal gland openings circular, minute; a single median opening on posterior edges of segments 4 and 5; segment 5 constricted in the middle (fig. 15) ..... CORIZIDAE

29b. Dorsal gland openings transverse, oval or slit-like; openings single or paired, usually in a pigmented area; segment 5 not constricted (figs. 10, 11) ..... LYGAEIDAE

A SIMPLE METHOD FOR *IN VITRO* STORAGE OF INSECT HEMOLYMPH[1]

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In conjunction with the use of paper electrophoresis for the separation of biochemical components of insect hemolymph (Brezner and Enns, 1958), the problem of obtaining fresh material for investigation "out of season" has arisen. Stephen and Steinhauer (1957) have demonstrated the variability of hemolymph protein constituents in the different life stages of Hexapoda, indicating that if comparative work is contemplated not only must the same species be used, but the same stage of development must be selected for study.

In naturally occurring insect populations, certain developmental stages may be available for only a short time during the year. An investigator is limited, therefore, to a relatively short period of time for collecting fresh specimens of a particular life stage with which to perform assay tests or other biochemical investigations. We have developed a method which permits the storage of the necessary material in quantity at a time when the insects are abundant.

The preservation of serological material is not new. Leone (1953) and Boyden (*in litt.*) have demonstrated the stability of serum proteins over a number of years, after the serum had been subjected to Seitz filtration, merthiolate treatment, or formaldehyde addition. All of these techniques, however, require sample sizes which are far in excess of those obtainable from insects, which range from .005 to .015 milliliters (five to fifteen lambda). Our technique, which we believe shows a great deal of promise, is the preservation of frozen hemolymph *in vitro* as described below. Although tests to date are only of four months' duration, there is no reason to believe that an extension of this time would affect the proteins materially. The enzymes which may be released from autolysing hemocytes are apparently inhibited in the frozen state, since they do not appear to affect protein patterns as found in fresh hemolymph.

The procedure is a simple one and fairly rapid, so that a large number of samples may be taken and preserved in a very short time. All serum taps are performed aseptically because previous experience has shown this to be an essential part of the technique. Rubber gloves are sterilized while worn by washing with 95% ethyl alcohol and resterilized with each new speci-

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men. Just prior to sampling, the insect is swabbed with an aqueous phenol solution. A small, shallow incision is made in the ventral thoracic integument and the issuing hemolymph drawn into sterile hematocrit or similar capillary tubes (Fig. 1). By means of a capillary bulb, the blood sample is drawn to the center of the tube after which both ends are sealed by flaming. The tube is then labelled and set in the freezing compartment of a re-

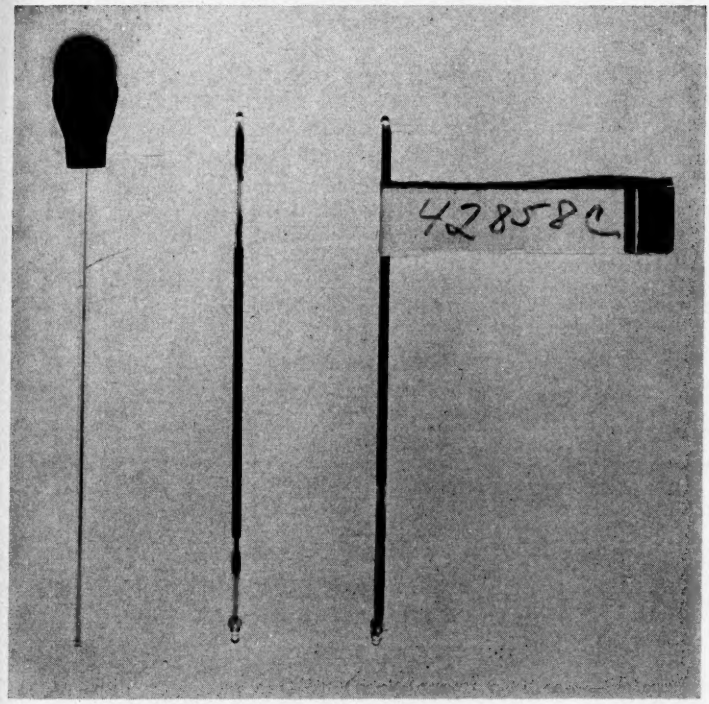

Fig. 1. Photographs of the storage containers for hemolymph. Left, capillary tube with bulb; center, sealed tube, filled with India ink for visibility; right, same with label affixed.

frigerator (0° to —2° Fahrenheit) where it is stored until needed. With practice, an insect may be tapped and the tube sealed in about one minute. The insect may then be preserved or, as with the scarabaeid larva, *Cotinis nitida,* and some other insects, returned to the rearing container for subsequent development.

A few alternate storage techniques were tried prior to adopting the procedure just described. The first attempt was immersion of the extracted hemolymph in liquid air followed by storage in a deep freeze refrigerator. This quick freezing worked out quite well. However, due to the limited availability of liquid air in most situations, this method was not considered

to be the most desirable. Furthermore, it was found to be unnecessary since the volume is so small that only 1½ to 2 minutes are required for the sample to be frozen solid in the freezing compartment. Conversely, a minute or two at room temperature is sufficient to thaw the frozen sample. The next attempt was at the other extreme of storage conditions, where the sealed tube was left in the refrigerator unfrozen (32° to 41° Fahrenheit). Subsequent electrophoretic separations with these samples exhibited very poor protein patterns, which have been tentatively explained as being the result of the action of enzymes produced by autolysing hemocytes. It would appear that the most acceptable method of preserving micro-quantities of hemolymph is by the simple freezing technique outlined above.

SUMMARY

Since particular stages of naturally occurring insect populations are not available at all times of the year, a method of storing hemolymph is necessary if continuous investigations are to be carried on. A simple technique of storing hemolymph has been developed. It consists of drawing off samples in standard capillary tubes, sealing both ends by flaming, and storing in the freezing compartment of an ordinary refrigerator. Hemolymph stored in this manner retains its properties over long periods of time and its constituents apparently are identical to those in freshly drawn samples.

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THE ELECTRON MICROSCOPE AS AN INSTRUMENT IN INSECT TAXONOMY

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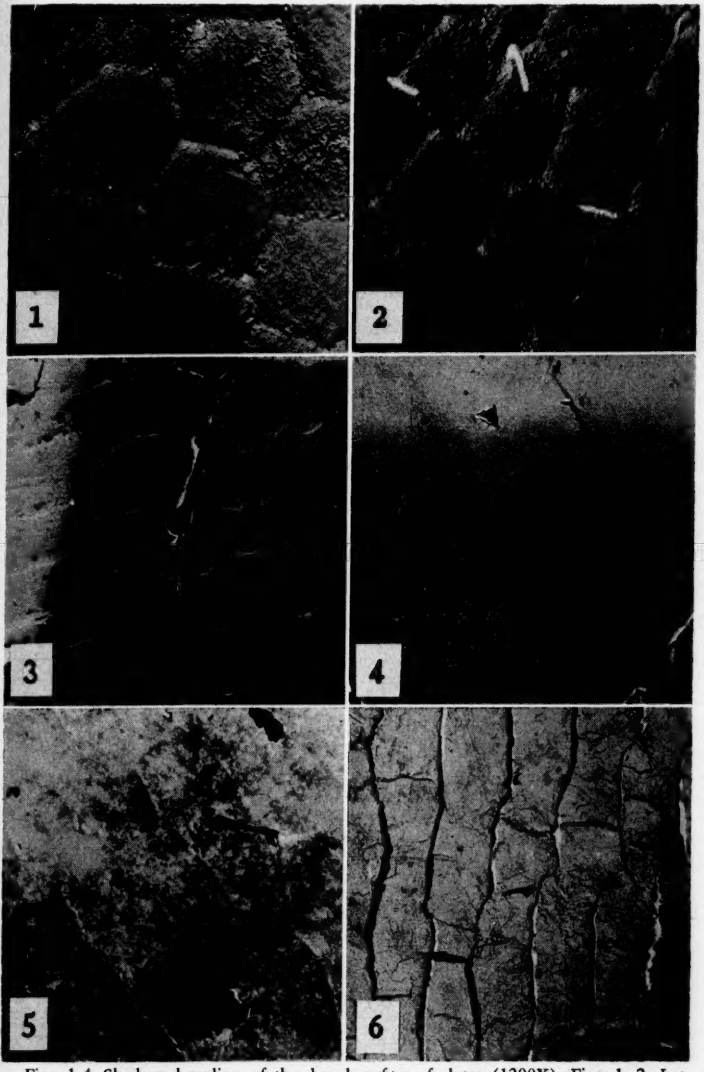
As far as the author is aware, the electron microscope has not been used by insect taxonomists. This is because in most cases ordinary microscopes are sufficient, in addition to which electron microscopy requires extensive training and equipment that is available in only a few laboratories. The purpose of this paper is to direct the attention of taxonomists to the possible use of this tool in the field of insect classification.

MATERIALS AND METHODS

The preliminary conclusions derived from this study are the results of the application of the replica technique to the cuticle of the beetles *Oryctes nasicornis, Cetonia aurata* and *Leptinotarsa decemlineata.* The dorsal surface of the elytron and the ventral side of the abdomen were studied in all



Figs. 1-4. Shadowed replicas of the dorsal surface of elytra (1200X). Figs. 1, 2. *Leptinotarsa decemlineata*. Fig. 3. *Cetonia aurata* (anterior part). Fig. 4. *Oryctes nasicornis* (anterior part).

Figs. 5-6. Shadowed replicas of the lower surface of the abdomen (1200X). Fig. 5. *Leptinotarsa decemlineata*. Fig. 6. *Oryctes nasicornis*.

three species, and in addition replicas of the pronotum of the first two were examined.

The replica method was applied, as described in a previous paper.[1] It is summarized as follows: Impressions were made on triafol rectangles moistened with acetone. An impression can be made without damage to the insect, except that in the case of soft parts, such as wings, tearing may result. The replicas were then shadowed in high vacuum, both at an angle and vertically, with SiO vapor. A thin layer of paraffin was then formed on the shadowed surface, and the triafol was dissolved in methyl acetate. The paraffin block was cut to the proper size, placed on the specimen screen shadowed surface downward, and the paraffin was dissolved in toluol, leaving only the shadowed film on the screen. The electron microscope used was a Siemans and Halske, type 100B.

The dimensions of structures in the micrographs can be estimated, given that one centimeter approximately equals eight microns, or that the magnification is about 1200×.

OBSERVATIONS AND RESULTS

On examining the elytra of *Leptinotarsa decemlineata,* a very distinct pattern of hexagons was noticed (figs. 1 and 2). The slender protrusions with light shadows occurring at the borders of the hexagons (fig. 2) probably indicate holes in the surface of the elytron. A different pattern was observed on the anterior part of the elytron of *Cetonia aurata* (fig. 3). No pattern was found on the elytron of *Oryctes nasicornis* (fig. 4).

The lower surface of the abdomen was also studied. A very distinct pattern of irregular, subparallel cracks was present in *O. nasicornis* (fig. 6). The pattern on the abdomen of *L. decemlineata* (fig. 5) showed some similarity to that of the elytron of the same species, although it was less distinct. In *O. nasicornis* there were found what seemed to be holes in the lower surface of the abdomen, the pronotum and the dorsal surface of the elytron. No striking pattern was observed in the pronotum of *O. nasicornis* or *C. aurata.*

From these observations, it appears that under the electron microscope the external form of the cuticle of one insect may vary from one region of the body to another. It also varies for the same region of the body in different species. Accordingly, species could be differentiated through the study of different parts of their cuticle. In cases where closely allied species are involved, finer details could be utilized. So far, however, closely related species have not been examined by this technique.

[1] Khalaf, K. T. 1958. Electronmicroscope study of the cuticle surface of the cockroach. Iraq Nat. Hist. Mus. Pub., No. 14.

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